SEPTEMBER 1959

Journal

VOL. 51 • NO. 9

AMERICAN WATER WORKS ASSOCIATION

Two parts—Part 1 (AWWA Directory is Part 2):

SAN FRANCISCO SUPPLY
Turner

BOND ISSUE CAMPAIGNS
Eastman

FLUORIDATION IN MAJOR US CITIES
Ingram, Moore

LEGAL ASPECTS OF UTILITY OPERATION
Taylor

ELECTRONIC BILLING AT ST. LOUIS
Briscoe

CONSTRUCTION OF FILTRATION PLANTS
Gordon, Salter, Williams, Spicer

MANUAL ON WATER METERS
AWWA M6

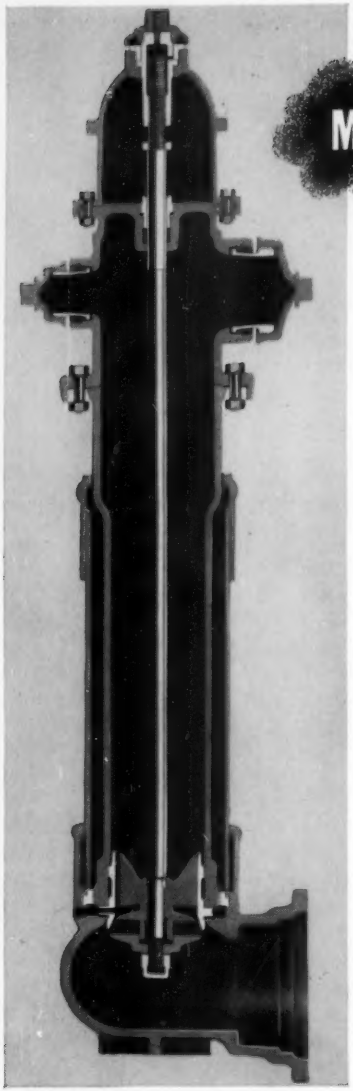
OHIO GROUND WATER QUALITY
Norris

CORROSION INHIBITION
Beecher, Dinkel, Corwin

ROLE OF CORROSION ENGINEER
Beermann

SIGNIFICANCE OF CHLORINE RESIDUALS
Baker

SecretaRay Faust
AWWA's Man Friday
as of Tuesday, Sep. 1



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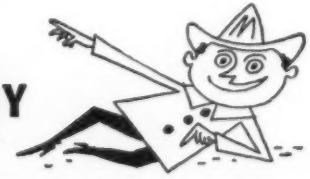

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Journal

AMERICAN WATER WORKS ASSOCIATION

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September 1959
Vol. 51 • No. 9

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Coming Meetings

AWWA SECTIONS

Sep. 14–16—Kentucky-Tennessee Section, at Lafayette Hotel, Lexington, Ky. Secretary, J. Wiley Finney Jr., Howard K. Bell, Cons. Engrs., 553 S. Limestone St., Lexington, Ky.

Sep. 16–18—New York Section, at Saranac Inn, Upper Saranac Lake. Secretary, Kimball Blanchard, Neptune Meter Co., New York Branch Sales Office, 2222 Jackson Ave., Long Island City.

Sep. 16–18—North Central Section, at Pick-Nicollet Hotel, Minneapolis, Minn. Secretary, L. N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

Sep. 23–25—Michigan Section, at Bancroft Hotel, Saginaw. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, DeWitt Rd., Lansing.

Sep. 27–29—Missouri Section, at President Hotel, Kansas City. Secretary, Warren A. Kramer, Chief, Water Supply, Div. of Health, State Office Building, Jefferson City.

Oct. 7–9—Chesapeake Section at Sheraton-Belvedere Hotel, Baltimore, Md. Secretary, Carl J. Lauter, 6955—33rd St., N.W., Washington, D.C.

Oct. 8–9—Intermountain Section, Pocatello, Idaho. Secretary, W. C. Hague, Chief Engr., Metropolitan Water Dist., 703 Tribune Bldg., Salt Lake City, Utah.

Oct. 14–16—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 18–21—Alabama-Mississippi Section (with Southwest Section) at Roosevelt Hotel, New Orleans, La. Secretary, Ernest Bryan, Southern Sales Mgr., McWane Cast Iron Pipe Co., Box 2601, Birmingham, Ala.

Oct. 18–21—Southwest Section (with Alabama-Mississippi Section) at Roosevelt Hotel, New Orleans, La. Secretary, L. A. Jackson, Mgr.-Engr., Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 22–24—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Oct. 28–29—West Virginia Section, at Chancellor Hotel, Parkersburg. Secretary, Hugh W. Hetzer, Engr., Union Carbide Chemical Co., Box 8361, South Charleston.

Oct. 28–30—Ohio Section, at Biltmore Hotel, Dayton. Secretary, J. Howard Bass, M-C-G Co. Ltd., 4942 N. High St., Columbus.

(Continued on page 10 P&R)

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Coming Meetings

(Continued from page 8 P&R)

Oct. 30—California Section (Business Meeting) at Hacienda Hotel, Bakersfield. Secretary, Roy E. Dodson Jr., Supt. of Production, San Diego Water Dept., Balboa Park, San Diego.

Nov. 4–6—Virginia Section, at Hotel Roanoke, Roanoke. Secretary, E. H. Ruehl, R. Stuart Royer & Assocs., 15 W. Cary St., Richmond.

Nov. 9–11—North Carolina Section, at Washington Duke Hotel, Durham. Secretary, D. Y. Brannock, Utilities Director, Burlington.

Nov. 15–19—Florida Section, at Hillsboro Hotel, Tampa. Secretary, J. G. Simmons, Plant Supt., West Palm Beach Water Dept., Box 1311, West Palm Beach.

Dec. 3–5—Cuban Section, Havana. Secretary, Juan Berasategui, Civ. Engr., Calle K, No. 303, Apdo. 22, Vedado, Havana.

OTHER ORGANIZATIONS

Sep. 13–18—American Chemical Society, Atlantic City, N.J.

Sep. 15–18—International Conference for the Protection Against Corrosion of Structures and Equipment of Hydroelectric Power Plants, Belgrade, Yugoslavia. Write: Secretary, International Conference, Box 711, Belgrade, Yugoslavia.

Sep. 21–25—Instrument-Automation Conference & Exhibit, Instrument Society of America, International Amphitheater, Chicago, Ill. Write: H. S. Kindler, Director of Tech. & Educational Services, 313—6th Ave., Pittsburgh 22, Pa.

Sep. 28–Oct. 1—American Welding Society, Sheraton-Cadillac Hotel, Detroit, Mich.

Oct. 5–16—Course on "Basic Radiological Health," R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: Chief, Training Program, 4676 Columbia Pkwy., Cincinnati 26, Ohio (or to USPHS regional office). The course will be repeated Nov. 9–20.

Oct. 12–15—Federation of Sewage & Industrial Wastes Assns., Statler Hilton Hotel, Dallas, Tex.

Oct. 19–23—APHA Annual Meeting, Convention Hall, Atlantic City, N.J.

Oct. 19–23—ASCE Annual Convention, Hotel Statler, Washington, D.C.

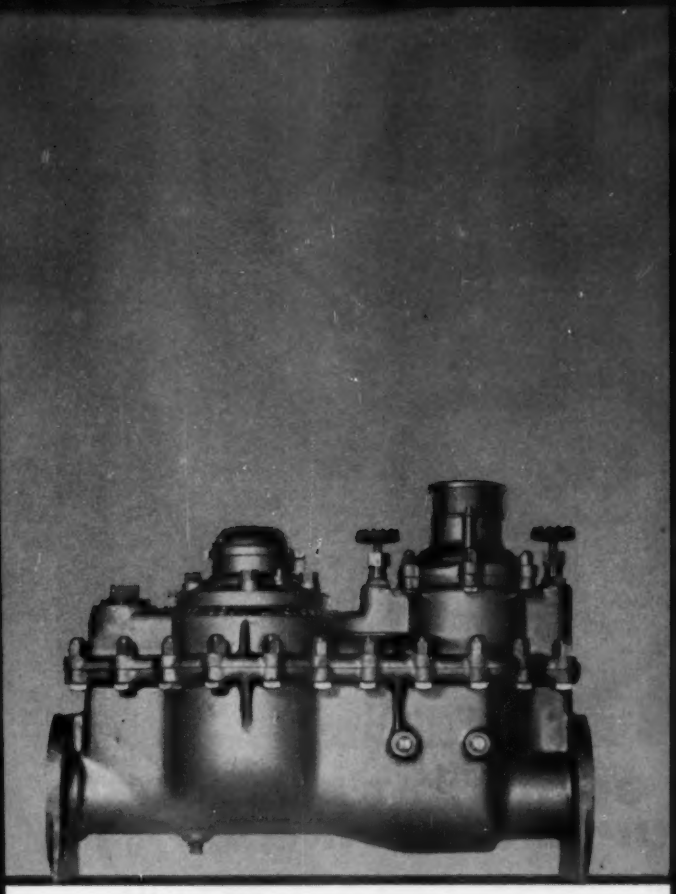
Oct. 20–22—ASA National Conference on Standards, Sheraton-Cadillac Hotel, Detroit, Mich.

Oct. 26–Nov. 6—Course on "Plankton Identification and Control," R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: Chief, Training Program, 4676 Columbia Pkwy., Cincinnati 26, Ohio (or to USPHS regional office).

Nov. 29–Dec. 4—ASME Annual Meeting, Chalfonte–Haddon Hall Hotel, Atlantic City, N.J.

Nov. 30–Dec. 4—Exposition of Chemical Industries, Coliseum, New York, N.Y.

Nov. 30–Dec. 11—Course on "Chemical Analyses for Water Quality," R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: Chief, Training Program, 4676 Columbia Pkwy., Cincinnati 26, Ohio (or to USPHS regional office).



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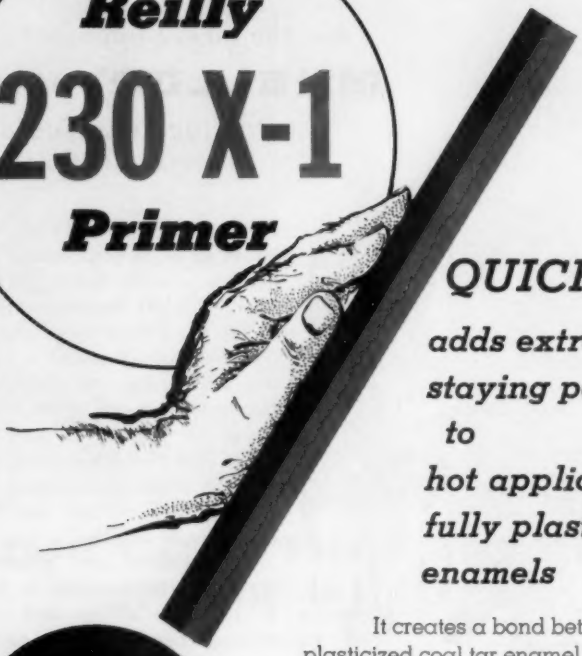
MUELLER CO. **DECATUR, ILL.**

Factories at: Decatur, Chattanooga, Los Angeles;
In Canada: Mueller, Limited, Sarnia, Ontario

Reilly

230 X-1

Primer



QUICKLY

adds extra staying power to hot application fully plasticized enamels

It creates a bond between fully plasticized coal tar enamel and metal that strengthens as it serves... that, when properly applied, increases the reliability factor of the application process on steel pipe and tank surfaces to a comfortable 100%.

Reilly 230 X-1 Primer

Reilly 230 X-1 Primer is

1. Quick drying, 20 minutes ± in clean atmosphere at 70°F.
2. Non-sagging and non-curtaining.
3. Economical to use (750 to 1400 sq. ft. gal. coverage).
4. Derived wholly from coal tar materials.
5. Acceptable to A.W.W.A. and government standards.

Specify REILLY 230 A. W. W. A. enamel with 230 X-1 primer. Also, soon to come, HS X-1 for Hot Service and QD-X-1 for Intermediate enamel.

REILLY TAR & CHEMICAL CORPORATION

1615 MERCHANTS BANK BUILDING
11 So. Meridian Street
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Reilly
ARMEX
Protective Coatings

BEAVER, IOWA
25,000 gallons

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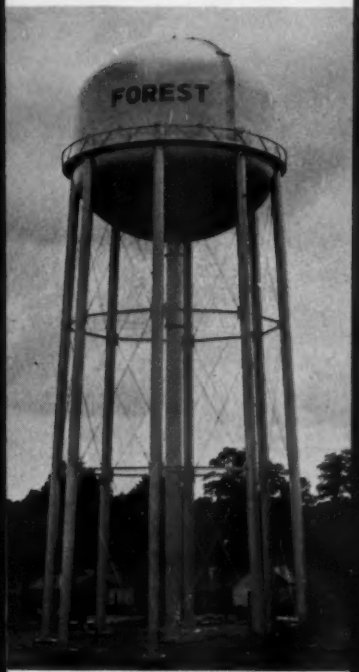
60,000 gallons

PDM
ELEVATED STEEL TANKS

BETTER ELEVATED WATER STORAGE

comes in all sizes to serve every need

Pittsburgh-Des Moines' resources as pioneer builders of steel elevated tanks include every type of structure, in every capacity to meet your individual water storage needs—fabricated and erected with expert craftsmanship and a responsible guarantee of satisfaction.
Write for our latest "Modern Water Storage" brochure: 20 pages of interest and information!



FOREST, MISSISSIPPI. 500,000 gallons

PUEBLO, COLORADO. 1,500,000 gallons

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Plants at PITTSBURGH, BALTIMORE, DES MOINES, SANTA CLARA, FRESNO, and STOCKTON, CALIF.

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EL MONTE, CAL.....P. O. Box 2012
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SEATTLE (1).....Suite 332, 500 Wall St.
SANTA CLARA, CAL.....631 Alviso Road
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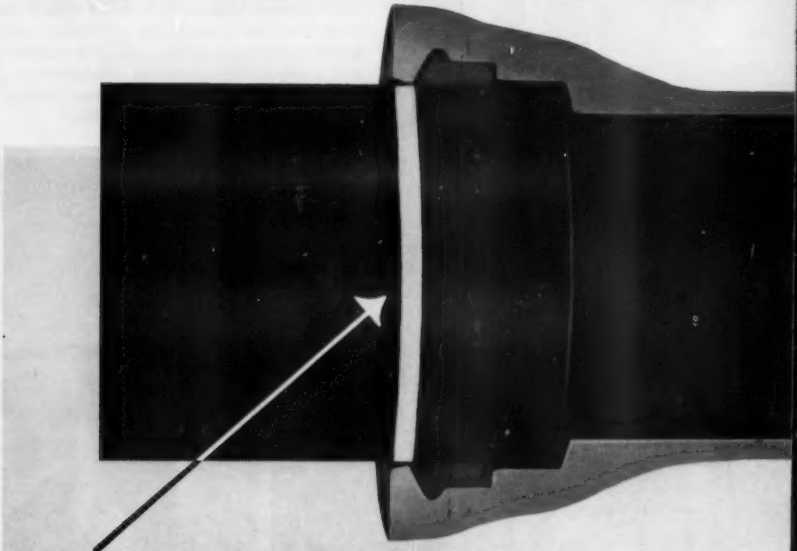
CLOW



This YELLOW STRIPE on

CLOW Bell-Tite Joint Pipe

is your guide line to a quick bottle-tight seal

This circular yellow stripe is painted on the plain end of each length of CLOW Bell-Tite Joint pipe. It serves as a guide in making up the joint, to provide a fast, positive visual check that the the joint is completely and correctly assembled.

The edge of the stripe farthest from the plain end measures approximately one-half inch less than the depth of the Bell-Tite bell. Thus, in assembly, the joint is made pressure-tight when the stripe is no longer visible.

The seal is achieved by the use of a single, thick-section, high durometer molded rubber gasket. When compressed in position by the entering plain end of pipe, it forms a pressure-tight seal with generous sealing area which permits ample deflection to meet casual curves or grades.

CAST IRON

with patented* Bell-Tite Joint

*Patent No. 2898131

MORE MAIN FOR YOUR MONEY

Costs less to buy

Only one accessory is required to make a pressure-tight seal with a CLOW Bell-Tite Joint —a single, molded rubber gasket. There are no extras—no bolts, no nuts, no followers, no couplings. This economical pipe is strong, tough, uniform and durable for long-life underground service. It is available in any specified thickness or weight class in accordance with ASA, AWWA, or Federal specifications from 3" to 24".

Costs less to install

Assembly is quick, simple and easy. Pressure-tight joint is formed instantly by merely inserting the rubber gasket and pushing the pipe home to its seat. It can be installed in a wet trench and even under water. Rate of installation usually is limited only by speed of excavation. It permits ample deflection for casual curves or grades. Bell-Tite Joint pipe is Underwriters' Listed for working pressures up to 350 psi. Available in diameters up to 24".

CLOW CAST IRON PIPE

JAMES B. CLOW & SONS, INC.

201-299 North Talman Avenue, Chicago 80, Illinois

Subsidiaries:

Eddy Valve Company, Waterford, N.Y.

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When you invest—
Get the best—
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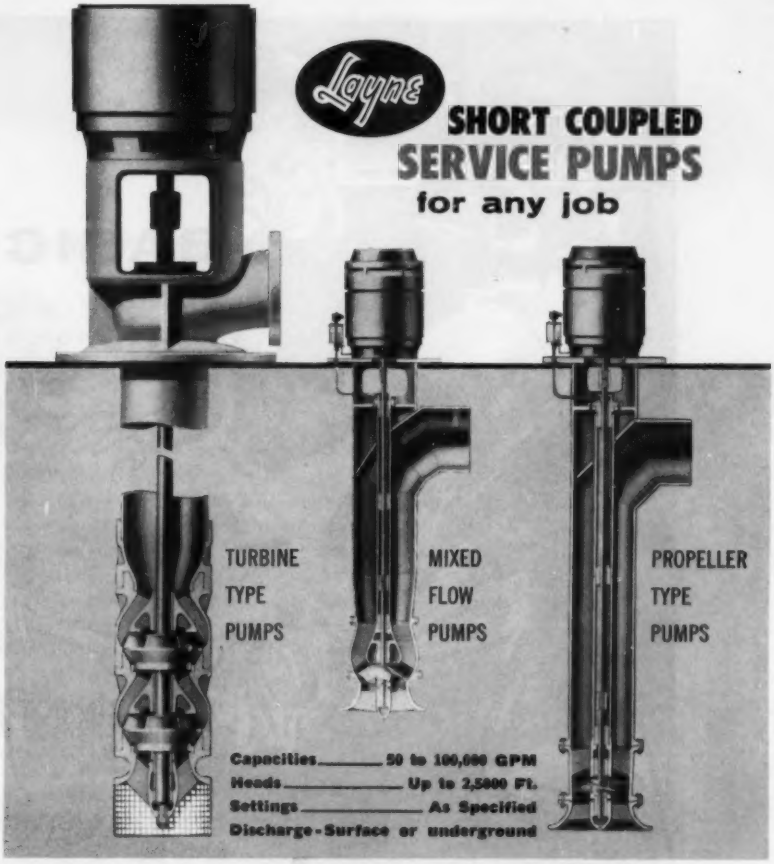

Top performance, high efficiency and less maintenance are factors which influence the selection of a short coupled pump. Layne Vertical Service Pumps fulfiill these requirements and offer the advantages of lower installation and operation costs, low submergence requirements, simple alignment, no priming and less floor space demands. For any short coupled pumping job . . . specify Layne.

Write For Free Bulletins:
LAYNE TURBINE TYPE SERVICE PUMPS—NO. 300
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World's Largest Layne Water Developers

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SALES REPRESENTATIVES IN MAJOR CITIES

Water Wells • Vertical Turbine Pumps • Water Treatment

A BATH WAS AN OCCASION in Grandfather's day. Setting up the tub, heating bucketfuls of water was a chore even the fussiest usually confined to one day a week—Saturday night.

EVERYDAY IS SATURDAY TODAY. With clean, pure water . . . carried through cast iron pipe . . . the shower or bath today is an accepted part of American living.

U.S. PIPE

FOR WATER, SEWERAGE AN

U. S. PIPE AND FOUNDRY COMPAN

...but better than ever today!

Mine-to-main control assures
U. S. Pipe quality in service

Water, harnessed and put to work, is the firmest base on which a community can build.

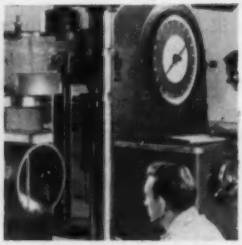
Water officials are doing an outstanding job keeping the nation's water pitcher filled. Cast iron pipe is their most dependable ally.

To furnish that dependability ... in every detail ... U. S. Pipe controls production every step of the way. From mine to final shipping U. S. cast iron pipe is subjected to intensive quality checks... checks to provide long life, efficiency, trouble-free service.

Quality is built into U. S. cast iron pipe.

CLEANING ORE. U. S. Pipe ore cleaning plant at a mine where ore is crushed and passed through separators to float off impurities.

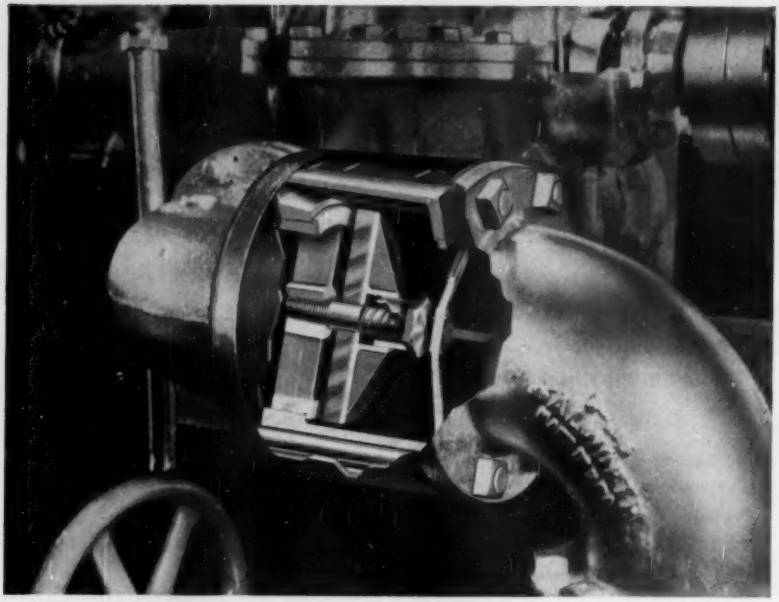
MOLTEN IRON in a measured amount is poured into a machine ladle, preparatory to the start of the centrifugal casting cycle.



VIGILANCE. Specimens of U.S. Pipe are periodically subjected to a ring crushing test in a 200,000 pound universal testing machine.

DUSTRIAL SERVICE

mingham 2, Ala. *A wholly integrated producer from mines and blast furnaces to finished pipe.*



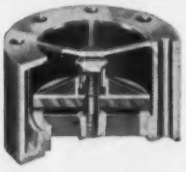
ELIMINATE BACK-DROP, SURGE AND HAMMER

When CPV silent, non-slam check valves are installed on the discharge of centrifugal pumps, the whole system is protected against waste and harmful surges. The need for expensive air cushions and other anti-hammer devices is eliminated.

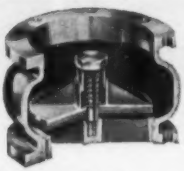
Spring-actuated, CPV check valves close automatically as soon as flow ceases. Back travel, which can be so damaging, is not required for closing.

Users report CPV valves easy to install and require no maintenance. Unique design includes bearing guides on both sides of disc and a full flow area in excess of pipe area. The valve operates in any position.

For complete specifications and prices write Combination Pump Valve Company, 853 Preston Street, Philadelphia 4, Pa.



STYLE "G"—2 to 10"



STYLE "GB"—6" and up

CPV SILENT NON-SLAM CHECK VALVES

ON THE HORIZON—A NEW ELEVATED TANK DESIGN

This new Graver design, appropriately named the Aquatore, is specially designed to complement the modern communities and industrial plants now being erected. Less maintenance cost, single foundation, low head range, and clean, distinctive appearance are a few of the advantages of this 300,000 to 3,000,000 gallon capacity elevated water tank. Pumps and other equipment may be installed within the column. The Aquatore is another product of Graver research. Write for descriptive literature.

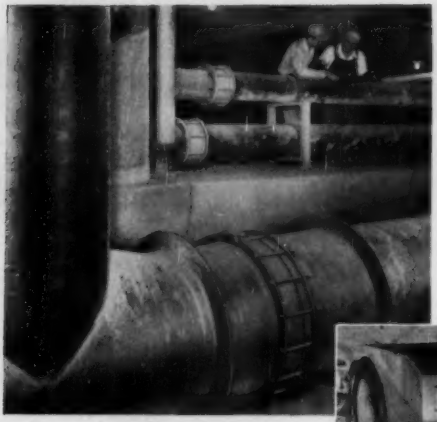
GRAVER TANK & MFG. CO.

DIVISION—UNION TANK CAR COMPANY

Plants and Offices Across America EAST CHICAGO, INDIANA

GRAVER®

Joining pipe the Dresser way...

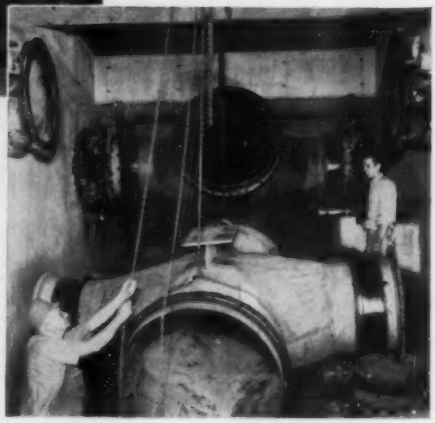


Always the easy way...

The 8-inch, 10-inch and 30-inch Dresser-Coupled lines illustrated here are part of the system used in servicing the Clague Road's advanced rapid-sand type filters.

often the only way!

This battery of steel crosses is in the new Clague Road Filtration Plant, designed by Havens and Emerson, Cleveland, Ohio. The Plant will carry a normal flow of 50-million gpd. Contractor: Hunkin-Conkey Construction Company.



Dresser® Couplings provide the essential leeway for bolting up cross flanges to valves in tight spots. They'll take deviation caused by settling concrete and remain bottle-tight... permanently! Dresser's vibration-proof properties protect valves and other expensive equipment, and protect the pipelines, too. With a Dresser Coupling, two man-minutes per bolt gives you a permanent, leak-proof joint that absorbs expansion-contraction movement, keeps maintenance problems to a minimum, and makes repairs easier if and when they do become necessary. For a free copy of "Dresser Couplings for Filtration Plant Piping" and the Dresser Sewage Treatment Plants booklet, write to Dresser Manufacturing Division, Bradford, Pennsylvania.

Bradford, Pennsylvania
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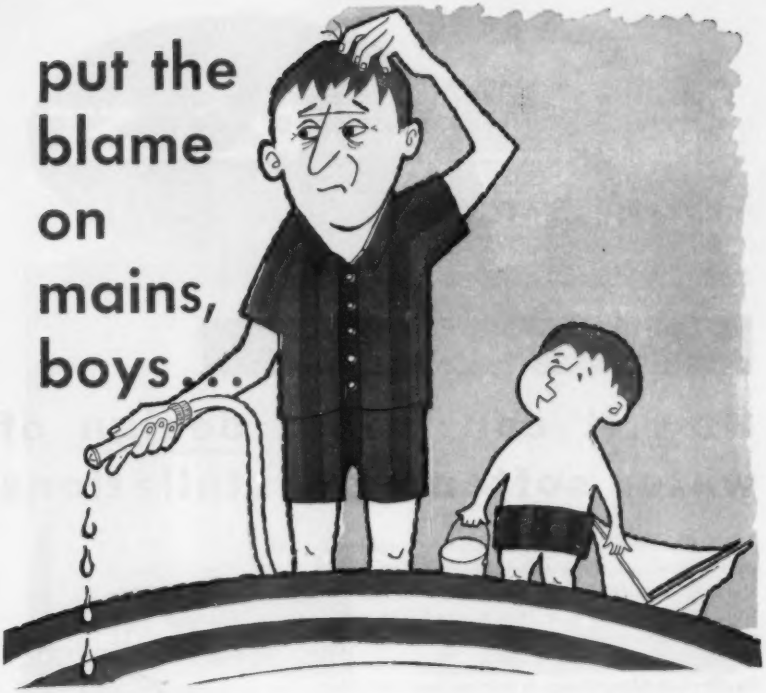
DRESSER
MANUFACTURING DIVISION

ONE OF THE DRESSER INDUSTRIES

put the blame on mains, boys...



Did you hear a lot of customer complaints about low water pressure last summer? After the spring's heavy rains which filled reservoirs to the brim all over the country, *there should be no water shortage.* The problem probably rests underground . . . mains and distribution grids choked by pressure-killing tuberculation and corrosion.

There's one sure cure for your pressure problem . . . the Centriline Process. Centrilining permanently increases carrying capacities in all sizes of pipe by eliminating tuberculation and corrosion forever. After loose scale and tubercules are removed from the pipe, the Centriline machine applies a smooth, uniform coating of cement-mortar to the pipe wall by centrifugal force. Fast and economical, Centrilining is accomplished with a minimum of interruption to surface traffic, since the pipes are lined in place and excavations are not required at laterals and services.

With the introduction this year of the new, small diameter Centriline machine, you can permanently protect all water lines from 4 to 144 inches in diameter. Send today for our new brochure which fully describes the Centriline Process.

CENTRILINE CORPORATION

A Subsidiary of Raymond International Inc.

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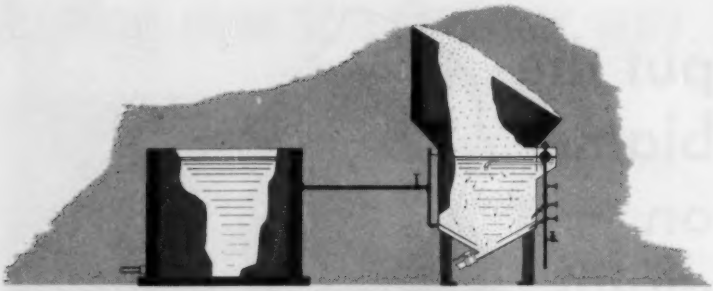
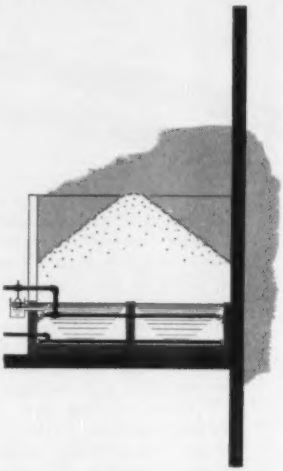
Branch Offices in Principal Cities of the United States, Canada and Latin America.



SALT STORAGE

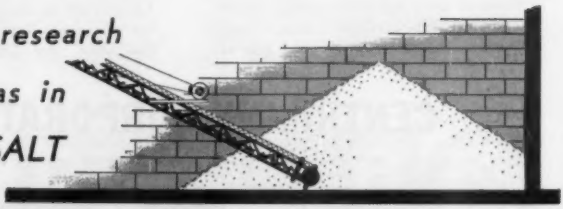
How it can affect design of water softening installations

The method used to store salt must be considered when planning a water softening plant. Dry salt storage, for example, requires different facilities from brine storage. And "wet storage" (dry salt stored under covering brine) has its own special design needs. Whatever method is chosen, however, its effect on plant design is greater than ever, since **more** salt and brine are needed in today's higher-capacity softening plants.



If you would like help in planning modern, large-scale salt-storage facilities, contact International Salt Company. With over 50 years of experience and continuing research in all phases of salt handling and brine production, International can suggest many new and practical ideas in connection with salt purchase, storage and dissolving for regenerating ion exchangers. This service is impartial and comprehensive. It costs you nothing.

Service and research are the extras in STERLING SALT



INTERNATIONAL SALT CO., INC., SCRANTON 2, PA. • **Sales Offices:** Atlanta, Ga. • Baltimore, Md. • Boston, Mass. Buffalo, N.Y. • Chicago, Ill. • Cincinnati, O. • Cleveland, O. • Detroit, Mich. • Newark, N.J. New Orleans, La. • New York, N.Y. • Philadelphia, Pa. • Pittsburgh, Pa. • Richmond, Va. • St. Louis, Mo.

KING
PAINT MAKERS SINCE 1834

The
SYMBOL OF AUTHORITY IN COATINGS SYSTEMS
for
POTABLE WATER STORAGE UNITS

310,000 Gal. Standpipe —
Gardiner Water District, Maine

250,000 Gal. Elevated Tank, Holden, Mass.

Two of the many hundreds of installations using KING Coatings — INSIDE and OUT . . .

KING TANK COATINGS are unique because

1. They are integrated systems — not merely coats of paint.
2. They were formulated specially and exclusively for potable water storage tanks and are not offered for sale for any purpose other than tank work.

FOR INTERIOR SURFACES

KING TRIPLE LEADKOTE (basic lead silico-chromate) or ZDO-120 (Zinc dust-zinc oxide) systems offer defense against corrosion, defense in formulation against improper application.

FOR EXTERIOR SURFACES

KING METAL COATERS offer color-fast weather and corrosion resistant protection in 3 Soft Grays and 2 Greens and Lettering Black, as well as Aviation White and International Orange for F.A.A. checkerboard patterns. TANK COATER ALUMINUM provides a truly streakless aluminum finish combining heavy pigmentation with a low-acid vehicle for maximum durable brightness.

Send for Bulletin 57070, a comprehensive 7 page booklet giving full analytical and application specifications on KING TANK COATINGS SYSTEMS. This is not a sales brochure, but a strictly technical work.

KING DIVISION **THE WILBUR & WILLIAMS CO., INC.**
Factory and General Offices
660 Pleasant St., Norwood, Mass.

the bigger your pumping problems

. . . the better your reasons for

giving them to

WHEELER-ECONOMY

You know how big problems can be, in selecting pumps for water works reservoir service. The Pumps you see here are specially designed and built to solve such problems. They're 36" Axial Flow Wheeler-Economy Pumps, each of which delivers 28,000 gpm. And they've been in continuous service for many years with only routine maintenance and modest operating costs.

If you're puzzled over which pumps to use for water works, municipal or industrial power plant service, drainage, irrigation or flood control, see C. H. Wheeler. Your representative can help you even if you need capacities exceeding 220,000 gpm and heads of 75 feet. He'll give you expert advice on pump design and construction, and station arrangement suggestions you'll find helpful.

Economy Pump Division

C. H. WHEELER MFG. CO.

19th and Lehigh Avenue • Philadelphia 32, Pa.

Whenever you see the name C. H. Wheeler on a product, you know it's a quality product

Centrifugal, Axial and Mixed Flow Pumps • Steam Condensers • Steam Jet Vacuum Equipment • Marine Auxiliary Machinery • Nuclear Products

the problem...

Problem: Move 30,000 gallons of sea water per minute through aggressive soil and ground water.

The Project: Magnesium-oxide plant for Michigan Chemical Company at Port St. Joe, Fla.

The Engineer: Cunningham-Limp Company, Detroit, Mich.

The Solution: 36" diameter Cen-Vi-Ro Water Pipe made with sulphate resisting Portland Cement and limestone aggregate; two inches of concrete cover for the reinforcing steel; six inches of loose oyster shell all around the pipe.

The Result: Service life estimated at more than 50 years.

Cen-Vi-Ro Pipe . . . engineered and made to your specifications . . . serves you better. When your job calls for concrete pipe, call Concrete Pipe Division, Vulcan Materials Company, Atlanta, Georgia.

CONCRETE PIPE DIVISION

VULCAN MATERIALS COMPANY

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Cyanamid

DRY—conforming fully to A.W.W.A. standards in ground, rice, lump or powdered grades, bagged or bulk.

LIQUID—for cleaner, easier, more economical operation—in tank wagons and tank cars; from nine shipping points.

THINKING OF CONVERTING TO LIQUID?

Your costs—and savings—can be quickly and realistically determined by a Cyanamid staff with years of conversion experience behind them. For product or technical service of any kind, call Cyanamid. You'll like the results!

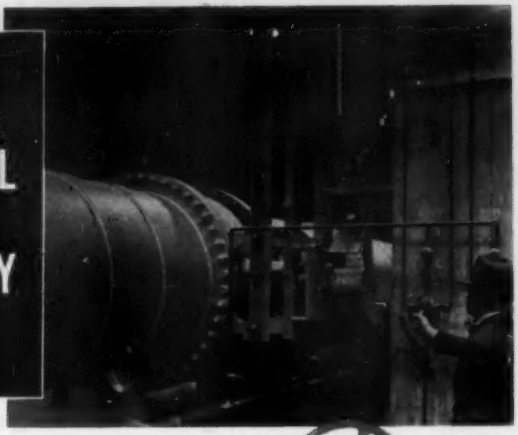
CYANAMID

AMERICAN CYANAMID COMPANY
Process Chemicals Department
30 Rockefeller Plaza, New York 20, New York

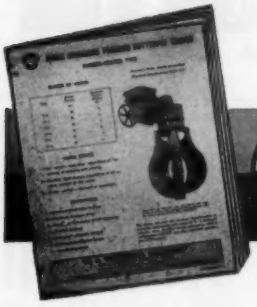
In Canada: Cyanamid of Canada Limited, Montreal and Toronto

at the Massena, N. Y., intake of the St. Lawrence Project

they've installed ROCKWELL AWWA BUTTERFLY VALVES



Yes, five 48" diameter Rockwell valves passing some 40 million gallons of water daily. Two of these valves at the canal intake are equipped with extended stems and worm gear handwheel units for remote control; the three valves in the power plant are equipped with hydraulic cylinders and 4-way control valves. All have Rockwell's exclusive Wedge-Lock rubber seat insert for drip-tight shutoff.



There are many such successful Rockwell valve installations for water applications. Bulletin 581 tells why.

ROCKWELL SINCE 1888 BUILT

BUTTERFLY VALVES

W. S. ROCKWELL COMPANY

2609 Eliot Street, Fairfield, Conn.

APCO Super De Lavaud CAST IRON PIPE

In sizes 3" to 24" in modern long lengths. Bell and spigot, roll-on-joint and mechanical joint.

For water, gas and sewage.

For The Best Connection You'll Ever Make Investigate The New ALTITE JOINT® by APCO

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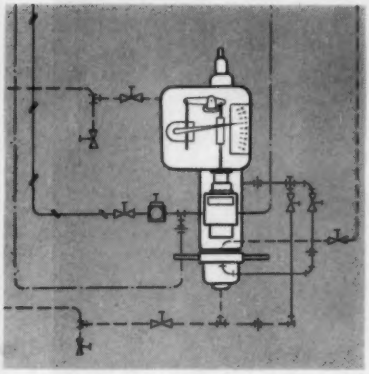
FLUIDICS

is a Pfaudler Permutit program providing a modern, imaginative approach — plus the specialized materials and equipment — for handling and processing and controlling more profitably the liquids and gases which are the lifeblood of our manufacturing economy.



FLUIDICS AT WORK

New pneumatic transmission system more accurate, more dependable

The diagram shows a typical setup for the new Simplex system for transmitting rate of flow and loss of head to a receiver.

Rate of Flow

The new Type PN transmitter combines the exceptional accuracy and range of a differential converter operated by a mercury float with the traditional dependability of pneumatic transmission.

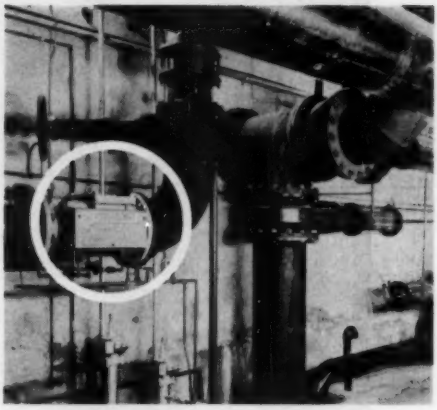
The transmitter consists of a differential converter which extracts the square root flow function from a primary and then positions a pneumatic motion transmitter. The transmitter produces a pneumatic 3 to 15 psig linear signal. A booster pitot diaphragm in the motion transmitter insures a low lag coefficient and fast transmission.

Besides getting a linear signal without using supplementary pneumatic relays, this new unit gives you point accuracy over wide ranges of flow with minimum differentials. The booster permits accurate transmission over long distances with minimum lag.

Loss of Head

A Type TD transmitter gives accurate readings to within ±1%. It uses no stuffing boxes or relay valves, so both installation and maintenance are simple and economical.

Connected to Simplex Pneumatic Gauges, this new system will give long years of accurate, dependable, trouble-free service.



FLUIDICS AT WORK

Modulair Flow Controller installs as easily as a piece of pipe

So simple is this new pneumatic rate-of-flow controller, you can install it in about the time it takes to install a piece of pipe.

The differential producer and the modulator lie in a single housing. The actuator is entirely enclosed in a case which mounts directly on the housing.

Result: No complicated piping or drain system to install and maintain.

For a bulletin giving complete specs and performance data, write to our Simplex Division, Lancaster, Pennsylvania. Ask for Bulletin 951.

Fast, dependable delivery insured by new plant

This is the new $2,000,000 home of our Simplex Division . . . an ultra-modern plant designed from front to back to give you fast, dependable service on valves and meters. New manufacturing techniques, updated assembly lines and ample manufacturing capacity and a complete staff of skilled workers have all been planned around the single objective of getting your orders to you on time and built to your exact specifications.

SIMPLEX

a division of PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes

From this cubicle comes advance proof of pump performance

Typical A-C pumping installation is this one in the District No. 2 Water Works at Pueblo, Colorado. Motors and control are also supplied by Allis-Chalmers.

This master control room of Allis-Chalmers pump test floor is far removed from public works installations. Yet engineers working here know exactly what your needs are — and which Allis-Chalmers pump will best do the job.

Performance testing like this is only one reason why A-C is recognized as a full-line leader in meeting the pump needs of municipals. "Teamed" motors and control; customized standardization of parts and materials; engineering assistance and nationwide service are others.

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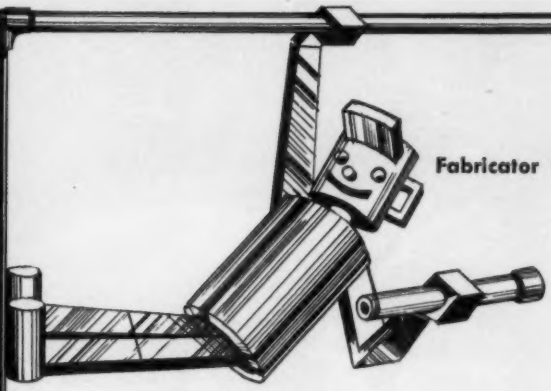

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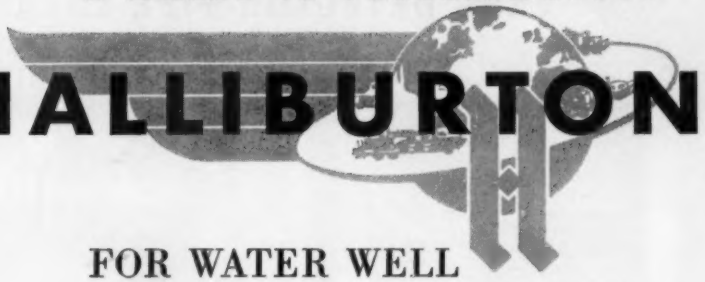

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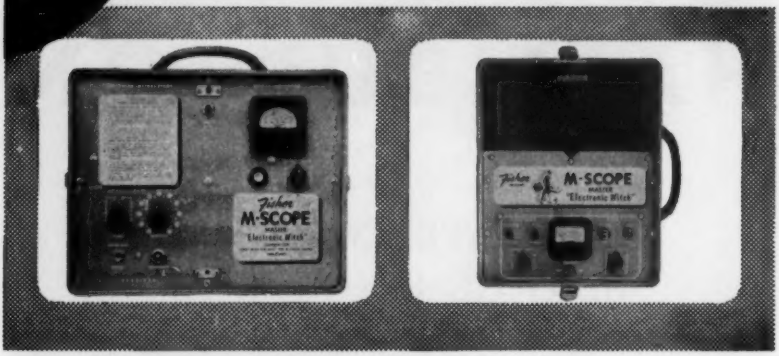

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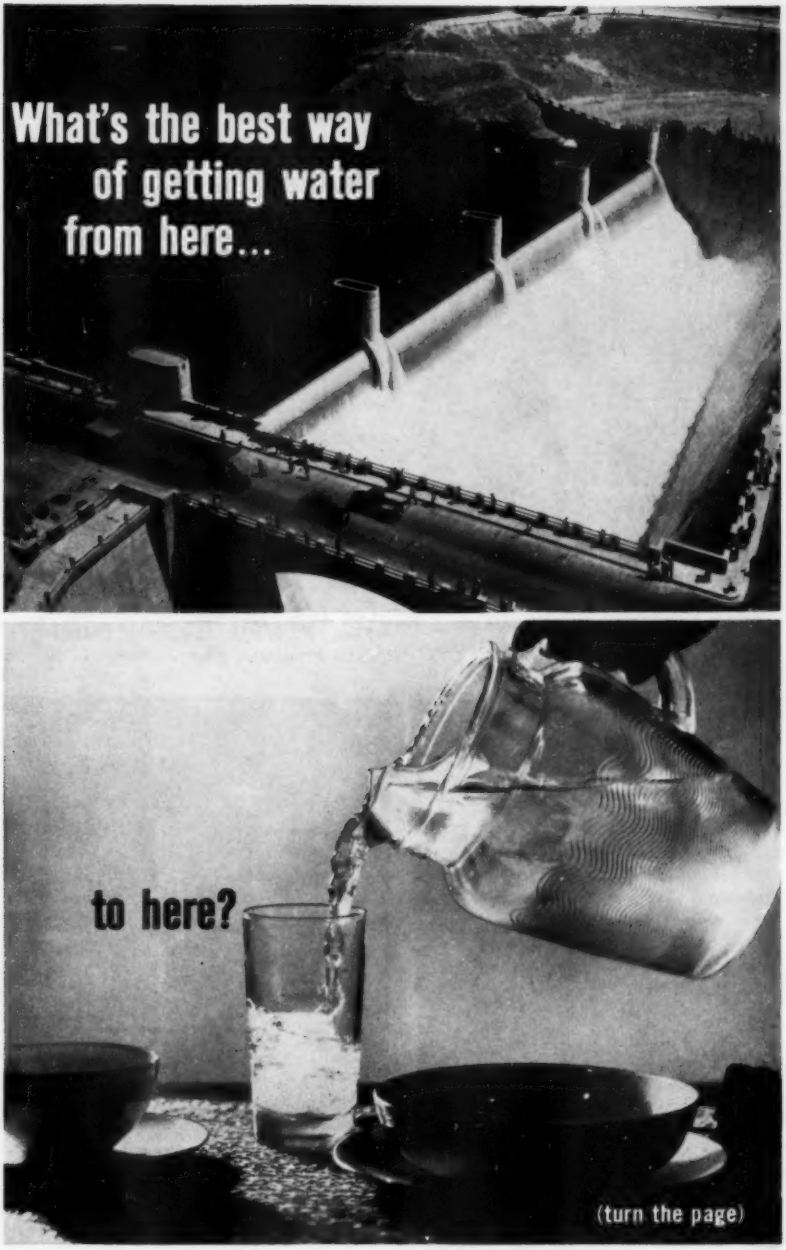
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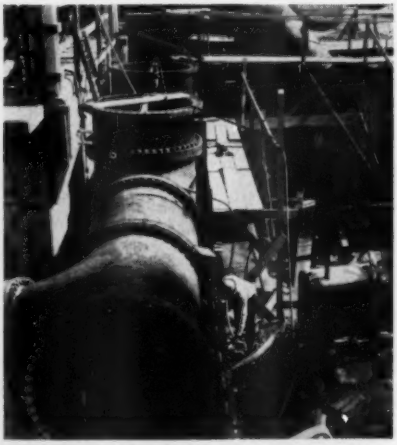

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San Francisco's Water Supply

James H. Turner

A paper presented on Jul. 14, 1959, at the Annual Conference, San Francisco, Calif., by James H. Turner, Gen. Mgr. & Chief Engr., Water Dept., San Francisco, Calif.

THAT part of San Francisco known as the Farallon Islands, 32 mi west of the mainland, was discovered in 1542 by Juan Rodrigues Cabrillo. It was 227 years later that Don Caspar de Portola and his followers first saw San Francisco Bay.

The Presidio of San Francisco and the mission that was called San Francisco and is now known as Mission Dolores—the first settlements in the area—were dedicated in 1776. The name San Francisco was first used by Carmeno, in 1591, when he renamed Drake's Bay, calling it Puerto de San Francisco.

Following the Presidio and the mission, a settlement was made on the bay at Telegraph Hill and was called Yerba Buena. This village was ordained San Francisco in 1847, and incorporated in 1850. After the discovery of gold in 1848, the population was reduced from nearly 900 to fewer than ten persons. From that time on the population increased rapidly until, in 1860, the first census recorded 56,802 residents in San Francisco. That figure rose to 775,357 in 1950 and is now estimated to be nearly 805,000.

Early Water Supply

Local springs and wells furnished San Francisco with an adequate water supply until 1851, when a company was formed to bring spring water from Sausalito in barges. It was delivered in carts and sold on water routes to subscribers by the bucketful and barrelful.

These sources sufficed until 1857, when the San Francisco Water Works began operations. Lobos Creek, a small stream flowing through the Presidio, was tapped, and its water was delivered by flume and tunnel to the Black Point pumps, at the north end of Van Ness Ave., where it was pumped to the Lombard and Francisco reservoirs, both of which are still in use. These reservoirs, in turn, fed a distributing pipe system, which extended throughout the settled portion

of the city. Some of these pipes, laid in February 1859, are also still in use. The first organized supply provided 2.0 mgd.

In 1851, the Mountain Lake Water Co. attempted to develop the waters of Mountain Lake and Lobos Creek without much success. Litigation between them and the San Francisco Water Works ended in the former's going out of business in 1862.

In 1860 George Ensign organized the Spring Valley Water Works, named after a spring located within the square formed by Clay, Washington, Powell, and Mason Streets. The utility's first supply, 200,000 gpd, came from Islais Creek and was transported through flume and pipeline from near Mission Street to a reservoir at 16th and Brannan Streets.

The Spring Valley Water Works, having more vision and enterprise than its competitor, secured water rights and property for reservoirs and pipelines in San Mateo County as the city

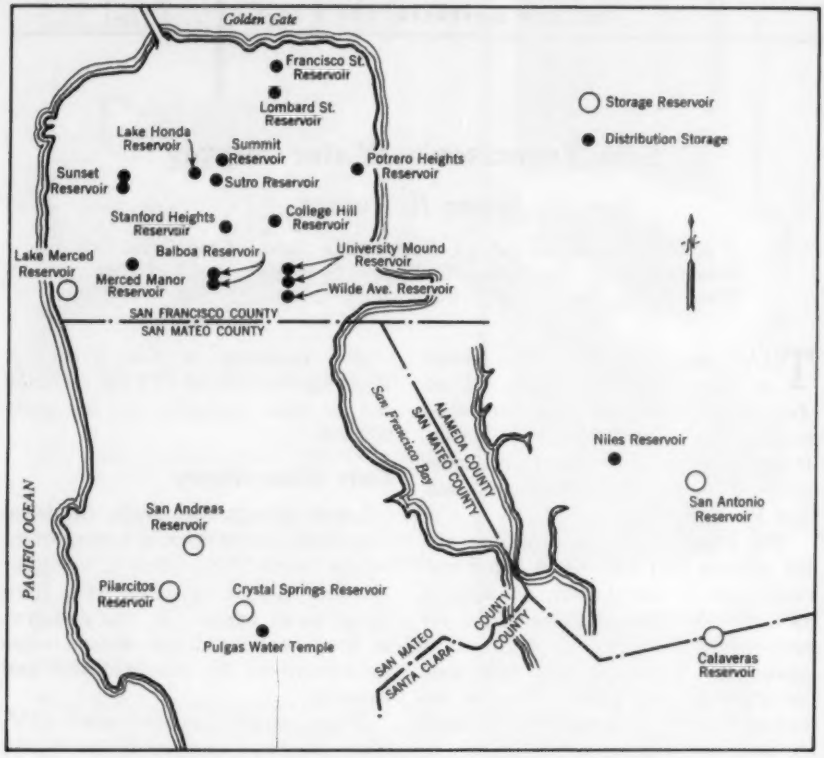

Fig. 1. San Francisco Water Department System

Shown above are locations of the principal reservoirs and distribution storage facilities discussed in the text. Lake Honda is for emergency use only and Balboa and San Antonio reservoirs are future facilities.

of San Francisco sought more adequate supply, tranmission, storage, and distribution facilities.

The first large distribution reservoir for the town, called Laguna Honda, was constructed in 1861 and received water from Pilarcitos Creek in 1862. This water was brought 32 mi by gravity through a redwood flume to the reservoir. Lake Honda, as it is now called, was put on a standby, emergency supply basis on completion of the north basin of Sunset Reservoir in 1938 (Fig. 1). The Pilarcitos Dam of today was started in 1864, completed in 1866, and was raised in 1874.

In 1865 the Spring Valley Water Works absorbed the San Francisco Water Works, thus gaining a monopoly. This condition lasted until 1930, when the city purchased the Spring Valley properties and took on the responsibility of providing water to the 634,394 people in the city, as well as to communities in San Mateo and Alameda counties.

Pilarcitos Dam was followed by construction of San Andreas Dam in 1868–70, upper Crystal Springs Dam in 1877, and the Lower Crystal Springs Dam in 1888. Lake Merced, a spring-fed lake within the present city limits of San Francisco, was put into service in 1877. This completed the original development of peninsula sources of supply.

Municipal Ownership

Beginning in 1867, friction between the Spring Valley Water Works and the consumers in San Francisco started a movement which resulted in its purchase by the city in 1930. In 1875 the city was advised to secure water rights and lands on Calaveras Creek, a branch of Alameda Creek in Alameda and Santa Clara counties. To forestall the city's acquisition of a source for its own use so close to home, the Spring Valley Water Works bought those rights and lands as well as others on the Alameda Creek system. Water was first brought to the city from the Niles Canyon in 1888, the Sunol gravels and Pleasanton wells in 1890, and the company completed Calaveras Dam in 1925, all as part of that system.

The defeat of the municipal-ownership proposal in 1875 resulted in an abandonment of the idea for a time. A new city charter became effective in 1900, however, stating that the public utilities "shall be gradually acquired and ultimately owned by the city and county." This mandate was the authority for the board of supervisors to order the city engineer to make a survey of possible water sources.

Appropriations and Development

In 1901 the city engineer reported fourteen possible water sources. The Tuolumne River system, later called the Hetch Hetchy system, was chosen because it provided:

1. A good quality of water
2. The largest safe yield available
3. The best reservoir sites
4. Freedom from conflicting legal claims
5. Power possibilities.

Appropriations of the waters of the Tuolumne River and its tributaries were therefore made by the city under California laws.

The reservoir sites were in the Stanislaus National Forest and in Yosemite National Park, the latter under the jurisdiction of the Department of Interior. On Oct. 16, 1901, application was filed for permission to construct the dams and necessary conduits and to use the reservoir sites. Permission was denied on Jun. 20,

1903, by Secretary of the Interior Hitchcock on the ground that he lacked the authority to make such a grant. The city continued its efforts to secure the necessary permission, being interrupted for about a year by the earthquake and fire of 1906. Secretary of the Interior James R. Garfield reopened the proceedings in San Francisco on Jul. 24, 1907. He approved the 1901 application on May 11, 1908, and his act became known as the "Garfield Permit."

The permit, which granted the city rights-of-way for conduits, dams, and reservoirs, was revocable under certain conditions and subject to certain restrictions. On the basis of the permit, the people of San Francisco voted a $600,000 bond issue on Nov. 12, 1907, and another for $45,000,000 on Jan. 14, 1910. These amounts were to have built the complete Hetch Hetchy system. A department called Hetch Hetchy was set up in the department of public works to plan, design, construct, maintain, and operate the project under the direction of the city engineer.

On revocation of a part of the Garfield Permit on Feb. 25, 1910, the city decided to go to Congress for a grant of the desired privileges. That year the city had a new plan prepared in which the entire Hetch Hetchy project was redesigned for a greater capacity, along very bold lines and according to more advanced engineering practices.

President Taft in 1910 appointed a board of Army engineers to investigate the sources of water that might be used by San Francisco. Three years later the board recommended the Hetch Hetchy source as the most accessible, the most economical for the city's use, and as having the greatest possibilities for hydroelectric development.

Raker Act

After protracted debate, Congress passed the Hetch Hetchy grant, known as the Raker Act, and President Wilson signed the bill on Dec. 19, 1913. For 12 years the city carried on negotiations, interrupted by the 1906 disaster, to secure a source of water supply of the best quality and of a quantity that was—and still is—expected to be sufficient, together with local sources, to meet the ultimate needs of the people within the city's service area.

Among the restrictions, powers, duties and privileges granted by the Raker Act are the following:

The Turlock and Modesto irrigation districts have the prior right to receive water they can beneficially use—up to 2,350 cfs of the natural daily flow—and for a 60-day period beginning with Apr. 15, 4,000 cfs of the natural daily flow for direct use and storage. The amount of water available to the city is dependent not only upon the total flow in the Tuolumne River but also upon what is necessary for its beneficial use in addition to the waters it had in 1913 or thereafter acquired.

The city was required to develop electric power, construct certain roads and donate them to the United States, pay an annual rental, and undertake and vigorously prosecute the completion of the Hetch Hetchy Dam. No power or water from Hetch Hetchy could be sold to a private party for resale, nor could any of the water be used for irrigation outside of the Turlock and Modesto irrigation districts.

The Raker Act expressly disclaims intent to interfere with the laws of California on the control or appropriation of water.

Before passage of the Raker Act, the city had, in July 1909, started ac-

tion on the development of the Tuolumne source by purchasing lands and water rights at Hetch Hetchy, the Cherry Basin, and Lake Eleanor. The city had constructed a diversion canal at the Lake Eleanor dam site, roads, bridges, and canals and started the construction camp now known as Camp Mather.

The "Freeman Plan" for Hetch Hetchy development was published in July 1912 after exhaustive studies of the project, and construction has, in general, followed that plan.

On Mar. 3, 1930, the San Francisco Water Department took over the operation of the system bought from the Spring Valley Water Co. under authorization of a referendum held May 1, 1928 on a $41,000,000 bond issue. At the same time a $24,000,000 bond issue was passed to construct the Coast Range Tunnels and San Joaquin pipeline.

Until Jan. 8, 1932, both Hetch Hetchy and the water department were under the city's department of public works. By authority of the new charter effective on that date, the two departments were taken over by the then newly formed public utilities commission, under whose jurisdiction they still operate, the former having jurisdiction over development of water and power at the source and transmission of water to Alameda East Portal in Alameda County, where the water department assumes responsibility. The transmission of power to the consumers is handled by Hetch Hetchy department.

Hetch Hetchy System

Three streams in the Sierra Mountains are being developed to provide water and power for San Francisco, the Bay Area, and the San Joaquin Valley under the water appropriation to the city by the state and the Raker Act authorization from Congress. These streams are Eleanor Creek, the Cherry River, and the Tuolumne River.

Power Plants

Under the terms of the Raker Act, four power plants were included in the plan, to assist in financing this extensive development and to make the greatest possible use of the water. The first plant was constructed 41 years ago at a location about 12 mi below the O'Shaughnessy Dam to provide power for construction purposes. That plant, called Early Intake Power Plant, is still in use; its capacity is just under 4,000 kw. The Moccasin Power Plant, constructed 33 years ago, is 30 mi downstream from O'Shaughnessy Dam. Its capacity is 82,000 kw.

The Cherry Power Plant and a 6-mi aqueduct from Lake Lloyd are under construction. The aqueduct will have a capacity of 410 cfs and include about 6,300 ft of tunnel. There will be a power drop of about 2,400 ft to the powerhouse. The plant is located a short distance upstream from the confluence of Cherry Creek and the Tuolumne River. The anticipated capacity is 131,500 kw.

Still in the planning stage is the fourth plant, which is to be known as the Canyon Power Plant. The water to operate this plant will come from Hetch Hetchy Reservoir through a tunnel and pipelines. The plant will be located on the Tuolumne River above the Early Diversion Dam and will have a generating capacity of 67,500 kw.

The city presently owns and maintains the 140 mi of high-tension transmission lines from the power plants to

Newark in Alameda County, at which point it is delivered into the system of the Pacific Gas and Electric Co., which supplies power to San Francisco's customers under a supplemental power "wheeling" agreement.

The watersheds of the three lakes or reservoirs are all above an elevation of 3,800 ft and are composed mainly of granite mountains. Mount Lyell is the highest with an elevation of 13,090 ft. All of the lands belong to the city or the federal government. The only residents are their employees, and the watersheds are under definite restrictive sanitary regulations to maintain the quality of the water.

Dams and Reservoirs

The O'Shaughnessy Dam (Fig. 2) on the Tuolumne River forms Hetch Hetchy Reservoir, which is the largest of the three reservoirs. Its capacity is 117.3 bil gal, and it drains a watershed area of 459 sq mi. The original dam was completed in 1923 and raised 79.5 ft in 1938.

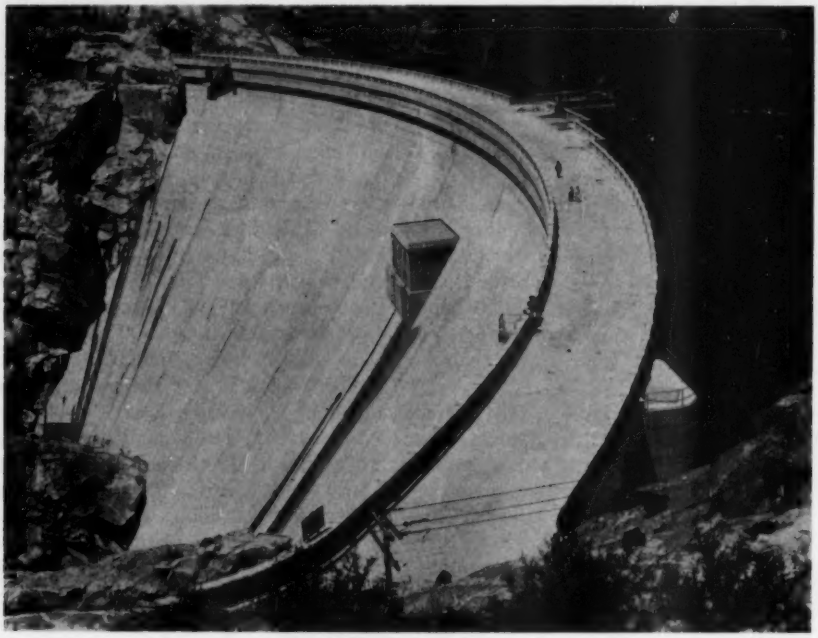

Fig. 2. O'Shaughnessy Dam

This concrete gravity structure impounds 117 bil gal when full and is the main supply for San Francisco

The Eleanor Dam (Fig. 3), located on Eleanor Creek about 5 mi northwest of Hetch Hetchy, forms Lake Eleanor, the smallest of the three reservoirs. It has a capacity of 8.8 bil gal and drains a watershed area of 79 sq mi. It was built 1 mi below the

outlet of the original lake and raised the water level about 35 ft. Eleanor Dam was completed in 1918 to provide water for year-round operation of the Early Intake Power Plant.

Cherry Dam (Fig. 4), completed in 1958, is located on the Cherry River a little more than 1 mi northwest of Eleanor Dam and forms Lake Lloyd, which has a capacity of 87.4 bil gal. The area of the lake's watershed is 114 sq mi.

There is now under construction a 6,400-ft long tunnel between this lake and Lake Eleanor, through which runoff from the Lake Eleanor watershed will be diverted for storage. The Lake Lloyd outlet will be through the tunnel to the Cherry Power Plant.

There are 32 sq mi of watershed between Cherry Dam and Eleanor Dam and the Cherry River Diversion Dam, 8 mi downstream but above the Cherry Power Plant. Cherry River water is here diverted into a canal which delivers the water to either the Early Power Plant or the Early Intake. The tailrace water may be released to the river or carried to the main aqueduct below the Early Intake.

Mountain Division

Tuolumne River water, including spill and releases at O'Shaughnessy Dam, and the runoff from another 29 sq mi of watershed may be intercepted 12 mi downstream at the Early Intake Diversion Dam and turned into the main aqueduct. The latter dam, built in 1924, has an impounding capacity of 37.5 mil gal. Water not diverted at this point flows 40 mi down the Tuolumne River to the Don Pedro Reservoir of the Turlock and Modesto irrigation districts.

Fig. 3. Eleanor Dam

This butressed-arch dam across Eleanor Creek, a tributary of the Tuolumne River, provides 9 bil gal of storage. The lake originally supplied water for Early Intake Powerhouse; now it is connected by a tunnel to Lake Lloyd.

From the Early Intake, the diverted waters travel through 11.6 mi of concrete-lined horseshoe section tunnel, 7.2 mi of rectangular section, and a short section of 9½-ft pipe at the South Fork. The design capacity is more than 400 mgd.

Moccasin Division

Water is discharged into Priest Reservoir, the forebay, or regulating res-

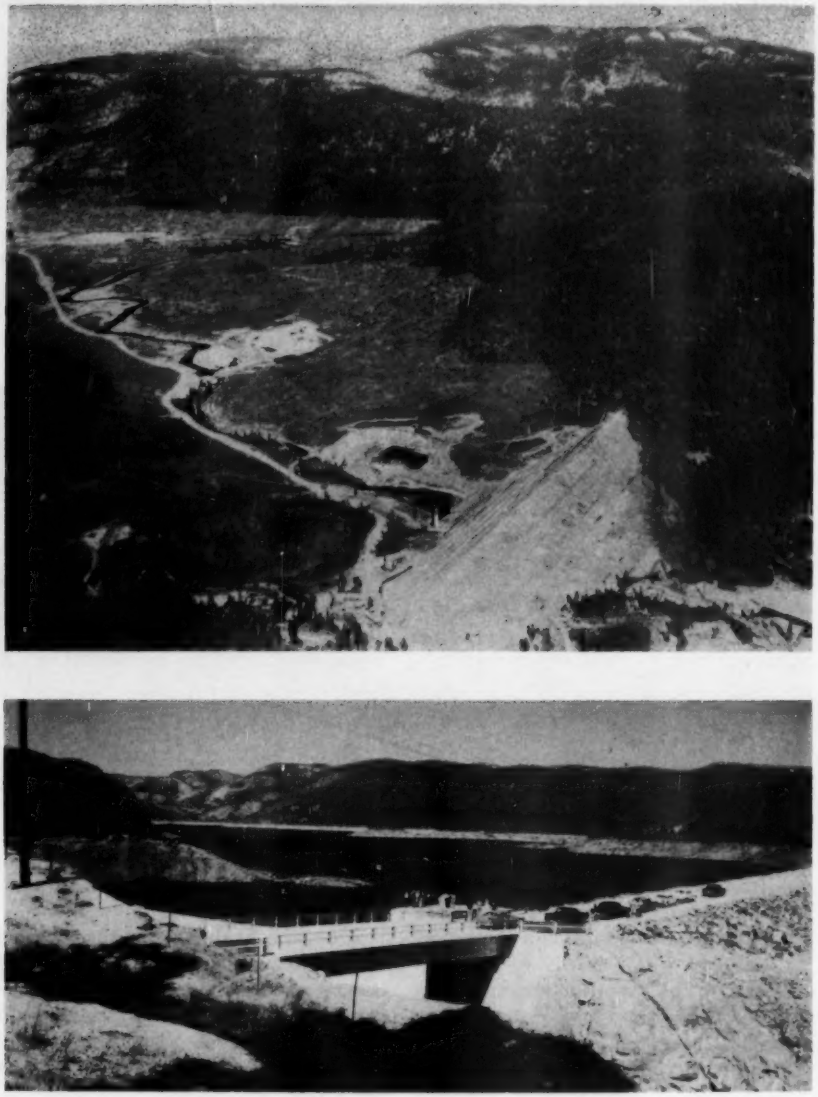

Fig. 4. Cherry Dam Before and After Completion

In the upper photograph Cherry Dam is shown almost completed but unfilled. The dam now provides both flood control and water supply storage.

ervoir, for the Moccasin Power Plant. The dam, built in 1923, has an impounding capacity of 77 mil gal. The water leaves Priest Reservoir through the mile-long Power Tunnel, 13 ft in diameter, which ends in a 40-ft surge shaft 160 ft high. From this, three pipelines 104 in. in diameter, one of them being capped for future extension, lead to the powerhouse. The other two branch twice, are reduced in diameter, and terminate in eight 11-in. diameter nozzles which discharge against the water wheels in the powerhouse at more than 500 psi of pressure.

Foothill Division

From the powerhouse tailrace, the water enters Moccasin Reregulating Reservoir to equalize the flow into the Foothill Tunnel. The reservoir was formed by the construction, in 1929, of a dam 1,500 ft downstream in Moccasin Creek. Moccasin Creek water, being unsatisfactory for municipal uses, was excluded from the reservoir by a reinforced-concrete diversion dam constructed in 1936. The normal flows are carried under the reregulating reservoir by means of a bypass conduit.

From the Moccasin Reservoir a 5.2-mi tunnel carries the water to the 0.5-mi Red Mountain Bar Pipeline, which is an inverted siphon under the Tuolumne River. At the outlet end of this pipeline, water that is not to be transmitted to the service area is released through a radial gate and a 22-ft wasteway into Don Pedro Reservoir. The aqueduct then continues through a 10.6-mi tunnel ending at the Oakdale Portal, in the east San Joaquin Valley foothills, where an overflow shaft is located.

San Joaquin Division

The San Joaquin Division is traversed by two pipelines between the Oakdale and the Tesla Portals. The latter is 8 mi south of Tracy, Calif. The pipelines, each 47.4 mi long, are known as San Joaquin Pipelines No. 1 and 2. The No. 1 line varies in diameter from 56 in. to 72 in. and is made of welded-steel cylinder pipe throughout. Pipeline No. 2 is 61 in. in diameter and is made of 18.7 mi of reinforced-concrete pipe and 28.7 mi of welded-steel–cylinder pipe. Flow in both lines is controlled at Oakdale and Tesla Portals by 60-in. butterfly valves, and pressure relief valves are installed at the San Joaquin River.

Coast Range Division

The water enters the Coast Range Tunnel at Tesla Portal. This concrete-lined tunnel is 25.2 mi long, and 10½ ft in diameter. The westerly end of the tunnel is at Alameda East Portal. This is the end of the portion of the aqueduct operated and maintained by the Hetch Hetchy authority and the beginning of the portion under San Francisco Water Department operation and maintenance.

Water Department System

Between Alameda East and West Portals the aqueduct consists of two pipelines known as the Alameda siphon. From the siphon the water enters the second section of the Coast Range Tunnel. The western end of this tunnel is known as Irvington Portal.

Bay Division

From Irvington Portal three pipelines carry water to Pulgas Tunnel;

they are known as Bay Division Pipelines No. 1, 2, and 3. No. 1 and 2 are parallel in the same right-of-way and cross San Francisco Bay. Pipeline No. 3 is located around the south end of the bay.

Pipeline No. 1 was built by the Hetch Hetchy Department in 1925 and is 21.3 mi long, and consists of 19.4 mi of riveted–steel plate pipe, 1.3 mi of concrete pipe, and 0.6 mi of cast-iron submarine pipe laid under Newark Slough and the navigable portion of San Francisco Bay.

Pipeline No. 2 was laid during 1935–36 and is 21.3 mi long, made up mainly of 62-in. concrete pipe and 66-in. welded–wrought-steel pipe. The submarine sections are two 54-in. steel pipes, each 0.6 mi long with 6-in. concrete jackets. At the westerly end of the submarine sections of both pipelines No. 1 and 2 there is a caisson with short 42-in. vertical risers connecting them with 60- and 76-in. pipes which are carried for 0.7 mi on a steel, through-riveted, truss bridge.

Pipeline No. 3 was completed in 1952 and is 33.9 mi long. There are 8.5 mi of 78-in. welded-steel cylinder, reinforced-concrete pipe; 17.1 mi of 72-in., cement-coated and lined, welded-steel pipe; 0.2 mi of 90-in. tunnel and 8.1 mi of 72-in., welded-steel cylinder, reinforced-concrete pipe.

All three of these lines are equipped with butterfly valves at the Irvington Portal and gate valves along the lines and at Pulgas Tunnel. There are cross connections between lines No. 1 and 2

Fig. 5. Calavaras Dam and Reservoir

The spillway is just visible in the lower right-hand corner. The dam was completed in 1925 and has an impounding capacity of 31.5 bil gal.

at four locations. Pipeline No. 3 was constructed around the bay to provide service to the South Bay area and to reduce the hazard of having all the main pipelines on trestles, on bridges, and under the bay.

Pulgas Tunnel is the next section of the aqueduct. It discharges through the Pulgas Water Temple, into an outfall canal, and into Upper Crystal Springs Reservoir. The Hetch Hetchy water has traversed river beds, tunnels, pipelines (above, on, and in the ground), under creeks, rivers, and the San Francisco Bay from O'Shaughnessy Dam to Crystal Springs Reservoir, a distance of 149.6 mi across the bay, or 162.3 mi around it.

The first consumers who receive water from the aqueduct are connected to the Alameda Creek Siphon. From that location to Crystal Springs the many service connections account for approximately half of the suburban consumption; the balance is taken north of Crystal Springs.

The first Hetch Hetchy water delivered to Lower Crystal Springs Reservoir was received there on Oct. 18, 1934. Between that date and Jul. 1, 1958, about 457.5 bil gal have been received at the Alameda East Portal. This is 55 per cent of the total released into the water department's transmission system for consumption.

Alameda Sources

The local sources of San Francisco water are divided geographically into Alameda and peninsula sources. These were developed by the Spring Valley Water Co. with some changes and additions made by the city. The Alameda source is the Alameda Creek drainage area. Three developments on this creek and its tributaries have been completed with the fourth, San Antonio Creek, which is now being explored for the design of a proposed storage dam.

Calaveras

The principal development in Alameda County is known as Calaveras Dam (Fig. 5); this dam and another dam on Upper Alameda Creek, which diverts water into the reservoir through a 9,709-ft tunnel, have a total catchment area of 135 sq mi in southern Alameda and northern Santa Clara counties. Calaveras Dam was completed in 1925 and has a capacity of 31.5 bil gal. The spillway was partially washed out and rebuilt in 1940.

The Upper Alameda Dam is of the reinforced-concrete, slab-and-buttress type. Construction of the tunnel was started by Spring Valley Water Co. and the tunnel and dam were completed by the city in December 1931.

Normal seasonal rainfall at the reservoir is 22.35 in. and the average production since 1934 has been 33.4 mgd.

Calaveras water may be released into the creek and returned to the system through the Sunol Filter Galleries, or it may be drawn into the Calaveras Pipeline, either directly or through aerators located at the dam. The Calaveras Pipeline is 5.8 mi long and discharges into the Alameda Siphon with direct connection to Sunol Pipeline, which serves the water department's Sunol headquarters area including the town of Sunol. These consumers may also be served from the Alameda Creek Siphon.

Sunol Galleries

Located 9 mi downstream from the Calaveras Dam are the Sunol Filter Galleries. These are a system of underground concrete galleries and

perforated pipe which collect the water percolating through the gravels. Creek water is impounded by Sunol Dam to increase the yield. The average yield of these gravels over the last 8 years has been approximately 6 mgd. This water enters the 4.9-mi Sunol-Niles Aqueduct at Sunol Dam.

At present there are seventeen usable wells. No water from these wells has been provided to consumers outside of the valley since April 1949; prior to that the wells produced an average of about 10 mgd for export. The 30-in. Pleasanton Pipeline transported this water to the Sunol Water Temple

Fig. 6. Crystal Springs Dam

The dam is shown overflowing approximately 150 mgd. The building immediately below the dam houses pumps and chlorination equipment.

Pleasanton Well Field

Another Alameda source is the Pleasanton Well Field located in the Livermore Valley near the city of Pleasanton, 5¼ mi from Sunol. There have been about 100 wells developed in this field; they vary in depth from 200 to 400 ft, but one is 734 ft deep.

where it joined the filter gallery water. The temple is a beautiful structure of classic design and it is one of the attractions that draws hundreds of visitors to the Alameda Division headquarters at Sunol.

Water from the filter gallery and well water, when used, flow through

the 4.9 mi Sunol-Niles Aqueduct to Niles Regulating Reservoir. The aqueduct consists of four concrete box flumes and five concrete-lined tunnels down Niles Canyon. The design capacity is 70 mgd.

Niles Reservoir is a concrete structure with a wooden roof and has a capacity of 5 mil gal. It acts as a regulating reservoir for the Irvington Pumps, located at Irvington 3 mi from the reservoir, and as a distribution reservoir for consumers in the vicinity of Niles. The connecting Niles-Irvington pipeline has a capacity of 32 mgd. The Irvington Pumps boost the water into Bay Division Pipelines No. 1 and 2. The pressure in the latter is sufficient to reverse the flow through the Niles-Irvington pipeline, thus furnishing water, if needed, to consumers being served from Niles Reservoir.

Peninsula Sources

The first of the peninsula sources to be used was Pilarcitos Creek, which flows to the west into the Pacific Ocean. Use of water from this source started in the 1862–63 season and has continued until the present. Construction of the dam was started in 1864 and completed 2 years later. The dam was raised in 1874 and the spillway was reconstructed in 1937. The reservoir has a capacity of 1.01 bil gal and a catchment area of 3.8 sq mi with an additional 0.6 sq mi that contributes by means of a side, or feeder, flume. The normal rainfall of about 45.6 in. is the highest for any of the local sources. The source's production, which is combined with that of San Andreas Reservoir, has averaged 7.7 mgd for the last 36 years, and has ranged from none to 15.1 mgd.

The reservoir outlet is through a 2.7-mi aqueduct of tunnels and pipelines having a capacity of about 40 mgd. The aqueduct crosses San Mateo Creek, where it receives water from the creek by a small diversion dam called San Mateo Creek Dam No. 1. This water is delivered directly to San Andreas Reservoir. Another small diversion dam downstream, San Mateo Creek Dam No. 2, diverts additional water through Stone Dam Aqueduct to the Crystal Springs canal and thence into San Andreas Reservoir.

Stone Dam, located on Pilarcitos Creek about 2 mi downstream from Pilarcitos Dam, was completed in 1871 and has a catchment area of about 2.1 sq mi. The water is diverted into San Mateo Creek and Crystal Springs Reservoir.

The next dam constructed in the Peninsula Division was on San Andreas Creek. This dam was constructed during 1868–70 and it was raised twice, once in 1875 and again in 1928. The reservoir has a capacity of 6.19 bil gal, a catchment area of 4.4 sq mi, and a contributing area of 2.5 sq mi. Normal rainfall is 37¼ in. The reservoir's production is added to Pilarcitos'.

Crystal Springs Reservoir is divided into an upper and a lower part. The Upper Dam was constructed in 1877 and raised in 1891 and 1924. There are two conduits through the dam, which empty into the lower reservoir.

The lower dam (Fig. 6) was constructed in 1887–88 and raised in 1890 and in 1911. It is on San Mateo creek below its junction with Laguna Ramundo from the south and San Andreas creek from the north.

One reservoir, Lake Merced, within the city of San Francisco, is spring fed and was used as a source of domestic water supply until 1933. Since then its water has not been used for such

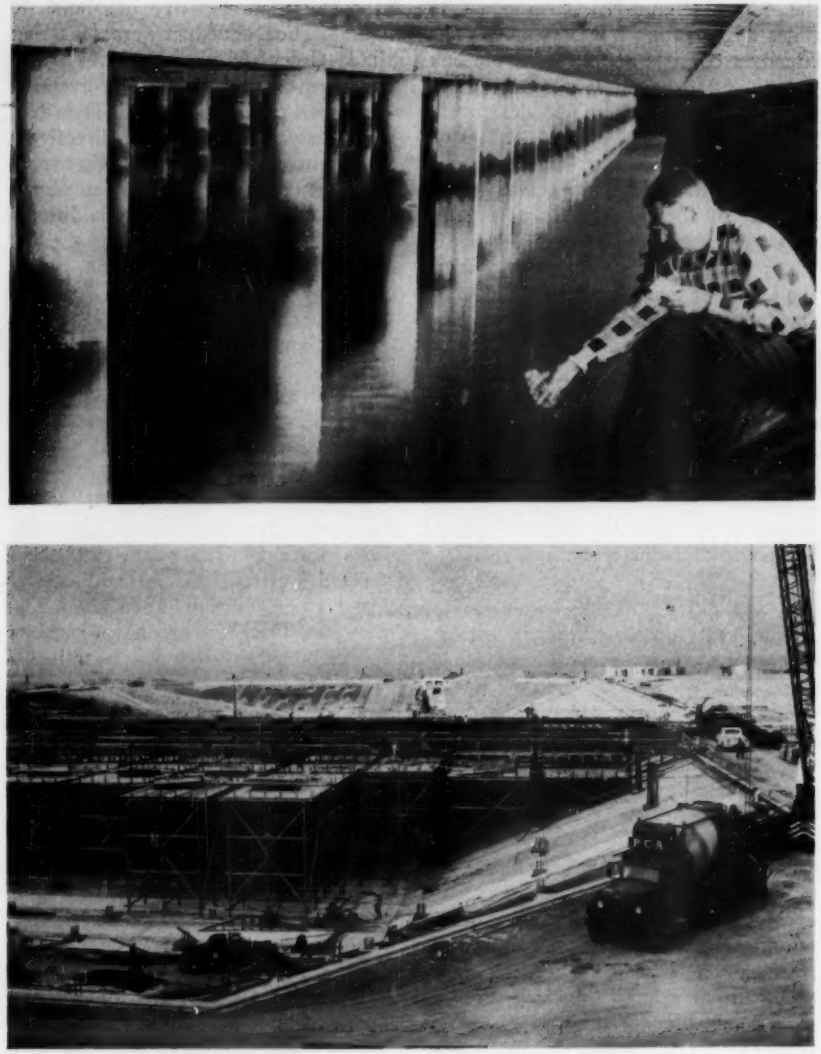

Fig. 7. Sunset Reservoir, North and South Basins

The North Basin (upper photograph) has been in use since 1938 and provides most of the supply for the residential area of San Francisco; its capacity is 89.4 mil gal. Another 87.3 mil gal of storage will be added to the reservoir on completion of the South Basin (lower photograph) now under construction.

purposes, but the reservoir has been maintained as a source for Harding Park and as a standby domestic supply. It is a natural lake emptying into the Pacific Ocean, but an earth dike across its outlet increases its capacity to 2.565 bil gal. All surface drainage is diverted to the ocean by storm drains.

Effects of 1906 Earthquake

No description of San Francisco and its water supply would be complete without a few facts concerning the effect of the 1906 earthquake. The San Andreas Fault, which caused the catastrophe, extends from the southeast through the easterly abutment of Upper Crystal Springs Dam, passes just west of Lower Crystal Springs Dam and through the easterly abutment of San Andreas Dam, and proceeds thence in a northwesterly direction to the ocean just south of San Francisco.

Damage to the three dams was negligible except to the outlet tunnel at Upper Crystal Springs, which was left with an offset in alignment.

The old pipeline from Pilarcitos Reservoir to the city lay practically on the fault line for some distance. It was destroyed and has never been replaced. The only then existing pipeline from Crystal Springs Reservoir to the city was badly damaged south of the city at Guadalupe Slough, where it was on wood trestle; the pipe was ruptured and thrown from the trestle, which was also badly damaged. The pipe has been relaid around the slough in solid ground. Other damage outside the city was minor.

Distribution Storage

In the city of San Francisco there are two receiving reservoirs, University Mound and Merced Manor, which are at elevations sufficiently low to receive, by gravity, water from the Hetch Hetchy Aqueduct and from Crystal Springs Reservoir. In addition to these, the Sunset and College Hill reservoirs can be supplied by gravity from San Andreas Reservoir. The water must be pumped into the fifth receiving reservoir, called Sutro. A sixth such reservoir, Lake Honda, which has been maintained on a standby basis since construction of Sunset Reservoir in 1938, was supplied by San Andreas Pipeline No. 2.

Two pipelines transmit Crystal Springs water to University Mound Reservoir. There is also a third pipe extending from Crystal Springs to Burlingame, where it also serves the Sunset Pipeline. Beyond Burlingame the third pipe has not yet been extended to University Mound Reservoir.

Crystal Springs Pipeline No. 2 is a 60-in., welded-steel pipe laid in 1937 from Crystal Springs through Burlingame, Millbrae, Baden, and South San Francisco to University Mound Reservoir. At each of these locations there are cross connections with one or more of the transmission lines into the city.

The Sunset Pipeline, a 60-in., welded-steel line, 20 mi long, delivers Crystal Springs water to Sunset Reservoir after boosting at Lake Merced pumps. A branch from San Andreas Reservoir may be used to deliver water from that reservoir to Sunset Reservoir by gravity. This Sunset line passes through Burlingame, Millbrae, and Baden.

San Andreas Pipeline No. 1 delivers water from that reservoir 11.9 mi through Millbrae and Baden to Merced Manor Reservoir. The portion of the

line running to Baden was constructed in 1870, and the balance of 6.8 mi was laid in 1907 and 1912.

The San Andreas Pipeline No. 2 is 12 mi long and was laid in 1928. This line passes through Millbrae and Baden and delivers water to Sunset Reservoir (Fig. 7) and, through a Crosstown pipeline, to College Hill Reservoir.

In order to maintain San Andreas Reservoir at a high level, a pumping station, with a lifting capacity of 55 mgd, was built at Crystal Springs Dam. The storage provided may be used by Sunset Reservoir and other areas of relatively high elevation.

The Lake Merced Pump Station also lifts Crystal Springs water to Sutro Reservoir. It was also constructed to pump water from Lake Merced and deliver it to either of these reservoirs.

There are two other pumping stations that have been used, on a standby basis, for similar purposes—that is, to lift Crystal Springs water to the Sunset Reservoir for distribution. One is located at Baden and the other at University Mound Reservoir in San Francisco.

City Distribution System

San Francisco varies in elevation from sea level to more than 900 ft above sea level. There are many hills of varying elevations; some are well known as Twin Peaks, Telegraph Hill, Mt. Davidson, Russian Hill, Nob Hill, and others, all of which require water service through a complicated distribution and pressure-zoning system.

Water pressures in the distribution system, as far as possible, are maintained at 40–80 psi. There are eleven distribution reservoirs in use for this purpose in the city, including the receiving reservoirs previously mentioned. Each of them serves a different area and is at a different elevation, ranging from 135 to 800 ft above sea level. Storage capacity varies from 0.5 to 140 mil gal each. On completion of the South Basin of Sunset Reservoir (Fig. 7) the total storage in Sunset Reservoir will be increased to about 177 mil gal. There are also nine tanks at elevations of 290–900 ft and capacities of 8,000–300,000 gal. These tanks serve relatively small, isolated areas.

In addition to the five pumping stations already mentioned, the system includes eighteen automatic electric stations with capacities of 50–4,500 gpm. These stations are within the city limits and supply both tanks and reservoirs at the higher elevations. Roughly 15 per cent of the water consumption in the city is pumped to elevations above those of the receiving reservoirs.

There are 1,105 mi of pipe in the city's distribution system, consisting of 943 mi of cast-iron pipe, 154 mi of wrought-iron and steel pipe, and 8 mi of asbestos-cement pipe. The oldest known main in service is a 4-in., cast-iron pipeline laid in 1859. Not including the tunnels used as aqueducts, there are approximately 200 mi of transmission mains, from 16 to 91 in. in diameter, under the jurisdiction of the water department outside of the city and 100 mi of 36–114-in. mains under the Hetch Hetchy department.

Watersheds

The city owns about 68,700 acres of land in the counties of Tuolumne, Stanislaus, San Joaquin, Alameda, Santa Clara, San Mateo, and San Francisco. Under lease or permit, more than 37,000 acres are being used

by others for a large variety of operations, all consistent with the city's water supply requirements. Such operations include a rock quarry, picnic grounds, parks, farms, golf courses, restaurants, book stores, and so forth.

The major part of the watershed producing domestic water for the Hetch Hetchy system are owned by the United States and are in Yosemite National Park and Stanislaus National Forest. Federal government agencies patrol the areas. The rest of such watershed lands, with very minor exceptions, are owned by the city and are patrolled by the regular caretaking, maintenance, and operating forces. There are eight reservoir keepers employed at the Hetch Hetchey reservoir sites.

The peninsular watershed lands are a part of the California Fish and Game Preserve. No fishing, hunting, boating, or picnicking is permitted, and the area is not open to the public. Fishing, boating, and hunting in the Alameda watershed and reservoir property are also prohibited. A public picnic grounds is maintained by the department at the Sunol Water Temple, however, and other recreational areas are provided along the Niles Canyon.

There are five water department employees, known as rangers, whose duties include patroling the watershed areas to watch for fires and to keep trespassers out. In addition, there are five reservoir keepers who not only guard the dams, outlet works, and water from damage or pollution but also operate the outlet controls and secure information for the records. These ten men assist one another when necessary and are deputized as officers of the law. These employees live in department-owned cottages on the reservoir sites and are always on duty.

System Maintenance and Operation

There are also five men who patrol the pipelines. They observe and report damage, encroachments on the department's property, leaks, and any other pertinent matters.

Maintenance and operation of the Hetch Hetchy system have their headquarters at Moccasin. There is a community of employees who live there in city-owned homes. Facilities for recreation and schooling are provided. There are shops for maintenance, repair, and replacement of electric and water facilities.

Maintenance and operation of the Water Department are carried on from three corporation yards, one in each of the department's divisions: city distribution, peninsular, and Alameda. The department's shops in the city, after securing the work by competitive bidding, manufacture standard gate, tapping, and detector check valves; leak bands; pipe lugs for attaching fittings to cast-iron pipe; and special copper connections for tubing and other fittings—all for departmental use. This division also bids competitively on some of the contracts for the laying of city mains and thus acts as its own contractor.

Treatment

The department maintains its purification division laboratory and headquarters at Millbrae. The laboratory has been certified by the California Department of Public Health. Laboratory and field tests for record and control purposes total more than 13,000 per year.

The soft mountain water from Hetch Hetchy is treated with lime to reduce its corrosivity. The results are very satisfactory. During 1957–58 about 1,160,000 lb of lime was used.

Algal growth in the local storage and impounding reservoirs is kept under control by the application of copper sulfate. Approximately 80,000 lb are used annually for this purpose.

To remove excessive turbidity, which sometimes occurs in the water flowing into Lower Crystal Springs Reservoir from San Andreas Creek, an alum plant and settling basin were constructed near the reservoir.

Disinfection of all water supplied is continuous, and during 1957–58 1,145,000 lb of chlorine was used at various stations. The water is first chlorinated at Tesla Portal before entering the eastern Coast Range Tunnel and after that at various locations along the transmission lines. The final chlorination takes place on withdrawal of the water from the city distribution reservoirs. Since 1955, practically all water leaving Crystal Springs and San Andreas Reservoirs has been treated with sodium silicofluoride.

The city does not filter any of the water. Hetch Hetchy water has a very low turbidity. Calaveras water that is stored shortly after the runoff starts is not used until April or May, when the turbidity has settled. Water from peninsular reservoirs had, prior to the 1955–56 season, satisfactorily low turbidity; in 1956, owing to heavy runoff and destruction of some ground cover on a part of the watersheds, it became relatively high. To reduce the turbidity, the alum plant mentioned above was constructed.

Metering and Communications

All consumer services have been metered since 1919. The service from the water main to and including the meter is the responsibility of the city; from there into and through the building, it is the owner's. There are 156,000 metered live services with about 160,000 meters, not including the 670 automatic-sprinkler connections installed throughout the system. The services vary from $\frac{5}{8}$ in. to 20 in.

The city has a private telephone system with full-time switchboard operation. In the Sierras there are a few privately owned lines that lease service for their regular use.

A two-way radio system is maintained in both operating departments. In the mountains it is the primary communication system between the facilities and vehicles. The water department has more recently inaugurated this type of communication and is expanding the system to give more and better coverage.

Conclusion

San Francisco has a water supply with excellent chemical and physical characteristics. It is sufficiently large to provide for the ultimate demand of the service area. No waterborne disease has ever been traced to this supply, and water use has never been restricted or rationed. The water is relatively soft and satisfactory for both industrial and domestic consumption. Treatment of the supply is continuous and carefully supervised.

Mechanics of Bond Issue Campaigns

F. H. Eastman

A paper presented on Jul. 15, 1959, at the Annual Conference, San Francisco, Calif., by F. H. Eastman, Secy., East Bay Munic. Utility Dist., Oakland, Calif.

WITH the increasing population of the United States and the consequent increasing need for more and more capital facilities, which, in turn, require more bond financing, the subject of bond issue campaigns is a most timely one. Because each campaign poses different problems and requires a somewhat different approach, no attempt will be made to suggest that there is any one best way to conduct a bond campaign. Perhaps, however, a general discussion of some of the fundamental principles and generally accepted techniques of planning a bond campaign will be helpful in suggesting ideas that can be used in planning for future bond issues.

Because examples of practical applications are usually helpful, the discussion will refer to the $252,000,000 bond election held in June 1958, at the East Bay Municipal Utility District, Oakland, Calif. This bond election was to finance a 10-year construction program needed to meet the growing water demands of the East Bay area. It was approved by the voters by more than 3½ to 1.

The subject of bond campaigns divides itself logically into four areas of discussion: [1] planning for a bond issue election, [2] organization of the campaign, [3] conduct of the campaign, and [4] follow-up after the election.

Planning for a Bond Issue Election

How far in advance of the bond election should the planning of the campaign begin? The answer to this question is that unless one is already planning for the next bond issue, regardless of how far off it may be, he is already behind schedule. This answer is based on a strong personal conviction that the greatest single influence on the success or failure of a bond election is the voters' attitude toward the public agency asking for approval of the bond issue. If the agency is viewed by the public as competent, honest, and friendly, then there exists a climate within which a straightforward, informative campaign can be conducted, with reasonable assurance that the public will accept the agency's explanation of the need for a bond issue and will, accordingly, authorize the bonds at the polls.

On the other hand, experience has shown that in communities where the agency is not regarded favorably by the public and where there is doubt about the efficiency or the integrity of the agency, then it is difficult and frequently impossible to secure public acceptance of the need for funds, whether they be for water or power systems, schools, roadways, or sewers. The most cleverly devised and skillfully executed bond issue campagin can seldom overcome an unfavorable commu-

nity reaction toward the agency and by itself assure passage of the bond issue on election day.

The first step, therefore, in planning a bond issue campaign is to develop a favorable corporate personality or image in the eyes of the public. Of course, all companies, organizations, or units of government should develop a favorable image whether or not they ever have a bond issue. The point is that such an image is almost essential to the success of the bond election, and it would be a serious oversight to discuss the subject of bond campaigns without recognizing this fact.

A favorable corporate personality cannot be established overnight or in a few months or even in a few years. Therefore, this phase of bond issue planning must always be working, even if the next bond issue is 5, 10, or more years away. How is a favorable corporate image obtained? Without going into the development of a general public relations program, the answer, briefly stated, is that a favorable image can be attained through a well-rounded public relations program conducted aggressively and consistently by the agency. This assumes, of course, that the agency is, in fact, deserving of a favorable corporate image by virtue of its efficient operation, honest management, and friendly attitude toward the public. No public relations program can make an inefficient agency look efficient to the public.

On the other hand, in the utility field, simply doing a good job is not enough. Most efforts to serve the public are carried on behind the scenes, out of public view, and the people must be shown what is being done to serve them. This is one of the objectives of a good public relations program, whether it is conducted in a large utility with the assistance of a trained professional staff or by the superintendent of a small, one-man organization. If a good job is being done and the people are told about it, a favorable corporate image and an atmosphere in which a bond campaign has a good chance to be successful can be developed.

Forecast of Public Reaction

Having developed a generally favorable relationship with the public, the agency's next step is to define clearly when and why the funds are needed, how much is needed, how they will be used, and how they will be repaid. This, of course, requires the combined skills of the entire administrative staff of the agency. Although detailed engineering and financial plans are not required at this time, a broad outline of the general program is needed to analyze intelligently the timing of the bond election, the probable sales approach, and the expected areas of opposition and support. Once the general plan is known, an analysis should be made of the probable public reaction to the plan and to the bond issue specifically. A few of the major questions to be answered are:

1. What actually is the attitude of the public toward the agency? Does the agency have the confidence of the public or is it regarded in an unfavorable light, and to what degree? In what geographical areas is the agency strongest and weakest?
2. Are the lines of communication with the public open and clear? If not, where are the weak spots?
3. Will the public be generally receptive to the explanation of the need for the program?
4. Will the public accept the program as being proper and adequate to meet this need?

5. What is likely to be the public reaction to the amount of the bond issue?

6. What has been the recent public reaction to bond issues generally, and to bond issues by this agency or similar agencies?

7. How will the public react at the polls to the specific bond issue?

Obviously, there is no way to determine in advance, with certainty, how people will feel and act on a matter that has not yet been put before them. Still, there are certain approaches that can be helpful in an effort to make such a forecast. First, with a little self-analysis, the agency can explore what its relations with the public have been in the past. It can draw on the experiences of other agencies that have been confronted with a similar problem. Matters can be discussed with those representing certain cross sections of the community by soliciting the opinion of civic leaders, the local chamber of commerce, and other business organizations. These discussions will undoubtedly give some indication of the magnitude of the problem to be faced and will show some of the specific areas of strength or weakness.

In many instances, however, the agency will want to know, with more certainty, just where it stands with public opinion. For this information, the public opinion poll has been very useful. Although such polls are not infallible, they certainly give more accurate information than almost any other tool one might use. Polling techniques have been developed scientifically and can be relied upon with a fair degree of accuracy if administered by a reliable, experienced firm. They are now commonly accepted by businesses and need not be very expensive. In the East Bay area, a public opinion poll was taken about a year prior to the bond issue election. The information obtained from the poll was heavily relied upon in planning the bond issue campaign.

Key Decisions

The preliminary analysis of the probable public reaction to the bond issue will dictate, to some extent, the answers to some key decisions that must be made before bond election plans can be formalized. For example, if the project to be financed is of considerable magnitude, it will be necessary to determine whether the voters should be asked to approve the entire bond requirement at one time or whether the bond requirement should be divided into several bond issues over a period of years.

The question of revenue bonds versus general obligation bonds should be explored both from the standpoint of financing and from the practical point of view that it is obviously easier to secure a simple majority vote on revenue bonds than the two-thirds vote required on general obligation bonds.

The timing of the bond issue election is an important consideration at this stage of planning. Should a special election be called or should the bond election be consolidated with the municipal, state, or national election?

It is virtually impossible to generalize the answers to such questions. Each must be viewed according to the circumstances that exist.

At East Bay, the proposal made to the voters was for a single bond issue for the total amount of the cost of the 10-year project, using general obligation bonds and combining the bond election with the state primaries in June. This proposal was based on the fact that the 10-year construction pro-

gram was an integrated plan that required the completion of all the major elements to make the plan fully operable. Approval by the voters of only a portion of the financing plan, followed by possible failure of a subsequent bond issue, would have been serious. On the other hand, submitting a single issue of $252,000,000 to the voters was probably unprecedented. The decision was not an easy one to make.

General obligation bonds were chosen because it was believed that they offered the most economical method of financing. Here again there were strong arguments against the decision, because revenue bonds offered the opportunity to get the voters' approval by a simple majority vote, instead of the two-thirds vote required for general obligation bonds.

It was decided not to hold a special election, because its cost to the district was estimated to be more than $150,000. Here, the concern was with public reaction to this additional expense, although it can be argued that a bond issue has a better chance to be approved at a special election than at a general election.

Verification of the Bond Proposal

Although at this stage of the discussion the bond election date is still many months away, it is now appropriate to mention the desirability of obtaining a verification of the bond proposal from some accredited, outside source. Unfortunately, the general public is somewhat inclined to feel that a public agency's own explanation of the need for the proposed project may be something less than entirely objective. The average voter generally feels that the projects can be built for less money.

To offset this typical reaction, it has been found helpful in many instances to have an outside organization thoroughly review the engineering plans, the cost estimates, and the financing plan, and to verify that the public agency's proposal is reasonable. Frequently, the original project actually will have been developed by a firm of consulting engineers, and the assistance of outside financial counselors will have been sought. In these instances, the endorsement by such firms serves the purpose well. If the agency has developed the proposal with its own staff, a review by an appropriate outside organization is often requested as a matter of good business principles, and will also serve as an acceptable verification to the public. Where circumstances do not justify the employment of outside professional services, a satisfactory result can be obtained by asking a small citizens committee to review the project. Such a committee can be offered far more information about the project than can be offered to the public as a whole. The endorsement of the project by such a committee will probably be acceptable to a majority of the voting public. The desirability of an independent verification is mentioned as a reminder that sufficient time must be allowed before the election for a review and possible revision of plans.

In the East Bay bond campaign, a consulting engineering firm was employed to make both an engineering and an economic review of the project more than a year before the election. This verification was heavily relied upon in presenting the issue to the voters.

Summary of Planning Phase

1. It is suggested that a well-rounded program of public relations be

developed and maintained at all times in order that an agency may always be in the strongest possible position to present a bond proposal to the voters.

2. A broad outline of the general project is needed at an early date as a basis for planning for the bond election.

3. An early analysis of the probable public reaction to the specific bond proposal will enable an agency to plan more intelligently its presentation to the public and to make important decisions regarding the bond proposal.

4. Verification by an outside group of the necessity for the project and of its engineering and financial features is important to secure public confidence in the program.

Organization of Campaign

Probably all public agencies are confronted by the same type of statutory limitations as to what can or cannot be done in presenting a bond proposal to the voters. Public funds cannot be spent to solicit the voter's approval of the bond issue. An agency cannot urge an affirmative vote or actively campaign in favor of the proposition. On the other hand, a public agency may, and should, fully inform the public of the need for the project, the description of the facilities to be built, the plan of financing the bond issue, and all related *factual* information that will enable the citizen to make his own decision on the proposal. This means that the actual campaigning must be left to the citizens of the community.

Legally and practically the division of functions between the district and a citizens committee should be as follows:

The *district* should: [1] provide the basic bond issue story; [2] disseminate factual information about the bond issue through its public information program; and [3] thoroughly indoctrinate its own employees so that they can answer the many questions expected from customers.

The *citizens committee* should: [1] raise the funds necessary to conduct the bond campaign; [2] prepare all promotional material and contract for all forms of paid advertising; and [3] conduct the campaign.

Preparation of the "Bond Issue Story"

The primary responsibility of the public agency in the initial organization of the bond campaign is to reduce the multitude of complicated engineering, construction, and financial details of the bond issue proposal into a factual presentation that is simple enough to be understood by the public, brief enough to permit wide distribution, and interesting enough to attract the attention of the citizen. This is truly a monumental undertaking! It is not dissimilar to an attempt to reduce the Bible to one paragraph, transcribe it on the head of a pin, and then develop some gimmick that will make everyone in the world want to read it. Still, the proper preparation of what can be called the "bond issue story" is so important to the success of the campaign that one must draw upon every skill at his command to come forth with an outstanding document.

To illustrate the necessity for perfection in preparing the bond issue story, it should be noted that a reliable advertising research organization estimates that each person is exposed more than 1,500 times a day to various stimuli directed to attract his attention. These stimuli come from TV and radio commercials, signboards, newspaper or magazine ads, direct-mail solicitations, telephone calls, and

a wide variety of other attention-provoking devices, each of which attempts to get a person's attention, his understanding, and to direct his course of action. If a bond issue story—which, at best, is a far cry from a million-dollar cigarette commercial—is to break through this "attention barrier," it must certainly be a short, sharp, and simple message. It is not to be implied that the East Bay bond issue story met all these requirements. Nevertheless, a review of its approach to the problem may be of some interest.

In the East Bay situation, the $252,000,000 bond issue was required to finance a 10-year construction program that included new dams on the Mokelumne River, a third aqueduct from the mountains to the East Bay, additional dams and terminal reservoirs in the East Bay area, new filter plants, pumping plants, storage reservoirs, transmission mains, buildings of various types, and a myriad of other facilities needed to complement a program of this size. The summary of the project by the East Bay engineering department was contained in a

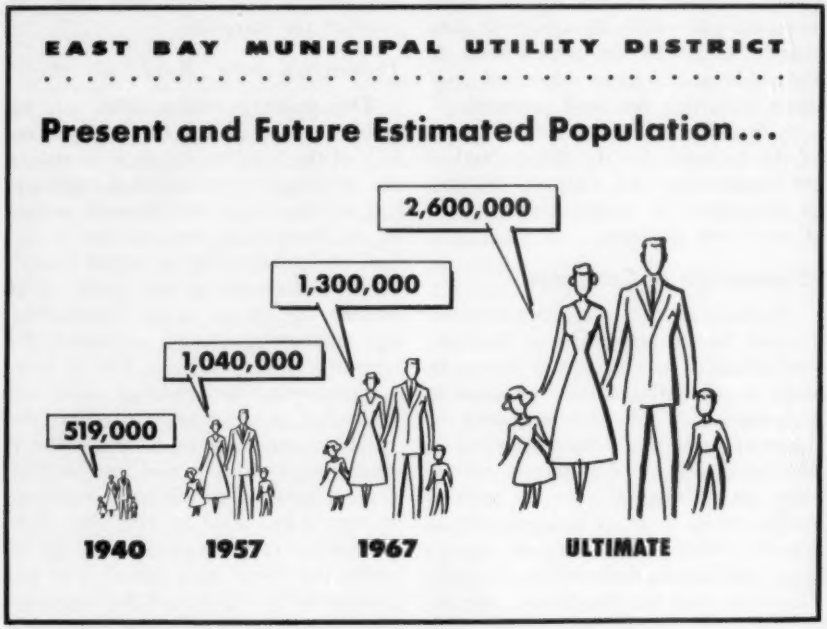

Fig. 1. Bond Issue Pictograph

This is one of the pictographs used to present the East Bay bond issue story. Pictographs were enlarged to 30×40 in. and also reproduced as slides for use by the speakers bureau.

document over 150 pages long. The consultant's report was 110 pages long. Other reports of the project filled many pages and covered a wide variety of subjects. It was finally concluded that the bond issue story should be limited to a few salient points, and that to attract attention, these points should be presented in graphic or pictorial form. The public opinion poll showed that the people would probably respond favorably if reasonable proof was presented that: [1] there was a need for the project, [2] the facilities included in the bond issue would meet this need, and [3] the bond issue could be financed without a tax rate or water rate increase. Accordingly, a set of charts or pictographs was devised to make these points (Fig. 1). Without going through the entire presentation—which, incidentally, was limited to 10 min of each public appearance—the points can be reviewed briefly.

First, population forecasts were presented and converted to future water requirements to indicate the growth of, and the need for more water in, the East Bay area. Next, with a series of charts, an attempt was made to explain the major features of the project by discussing present capacities of the various facilities and the proposed new capacities upon completion of the project. In presenting these particular charts, the objective was not to discuss projects as such, but simply to show the great expansion that was needed to meet community growth. A summary of the total construction cost was given as an introduction to the financing plan. It was also emphasized that the bonds could be financed without an increase in taxes or water rates. The graphic presentation was concluded with a direct quote from the consultant's report, in which it was verified that the financing could be accomplished without tax or water rate increases.

This, basically, was the East Bay bond issue story. Upon it was based an entire campaign. All other informative material prepared by the district and the promotional material prepared by the citizens committee were keyed to this basic bond issue story.

Organization of Citizens Committees

As mentioned previously, it is the function of the citizens committee to raise campaign funds, prepare promotional materials, contract for advertising, and conduct an aggressive campaign to persuade the citizens to vote for the bond issue. A committee is necessary because a public agency cannot legally engage in these activities. Furthermore, the effectiveness of a citizens committee is much greater than that of the public agency, because it represents a broader base of public opinion and manpower.

There are, probably, as many ways to organize a citizens committee as there are reasons for forming it. The best way depends on the size of the job to be done and the number of people willing to help. The citizens committee formed in connection with the East Bay bond issue actually consisted of two groups: an executive committee of working volunteers and a committee of 1,000, which represented citizens throughout the district who permitted their names to be used on publicity and advertising endorsements of the bond issue.

The executive committee, which started to organize 6 months before the election, included a general chairman and two co-chairmen selected be-

cause they were outstanding civic leaders in the community and because of their proven ability to pitch in and do the job. Two persons were selected from each geographical area within the district to serve as area chairmen from their city or locality. They were primarily responsible for securing speaking engagements in their areas, getting volunteers for the Committee of 1,000, and keeping the executive committee posted on the progress of the campaign in their respective areas. Chairmen of four working committees—finance, publicity and advertising, endorsements, and speakers bureau—were also appointed to serve on the executive committee.

Finance committee. This committee was responsible not only for raising funds, but also for an accounting of such funds and, above all, for controlling expenses. The committee consisted of men in the community known to be good fund raisers. A fundamental principle of election campaigns is that no commitment should be made until there is cash on hand to pay the bill. Sound businessmen will not serve on citizens committees that have unpaid bills after the campaign is over and no money to pay them.

With regard to the actual mechanics of fund raising, it has been observed that the amount of money collected is in direct proportion to the number of personal solicitations made by the members of the finance committee. Direct-mail, form-letter appeals seldom return the cost of preparation and mailing. Much better results seem to be obtained when the committee prepares a list of persons known to contribute to civic activities, or at least capable of doing so, and then assigns members of the committee to make personal solicitations.

Publicity and advertising committee. This committee should consist of volunteers who are experienced in the general field of advertising and publicity. Usually, the membership is drawn from newspaper, radio, and TV executives and from executives in fields of outdoor advertising, transit advertising, and department store advertising. It is the function of this committee to develop and prepare the many promotional materials needed in the campaign and to prepare and place all forms of advertising. Preparation of press releases and feature stories is another of its functions.

When the campaign budget permits, the employment of a paid, professional campaign director is strongly recommended. Because the citizens committee is, at best, a volunteer group, and because the public agency cannot enter the promotional activities of the campaign, there is a real need for a paid staff member who can be assigned the responsibility of overall coordination of the campaign. In a large campaign, a headquarters office is needed as the focal point for all activities. Providing for and staffing such an office can generally be handled best by a paid campaign director. Similarly, the contracting for all campaign supplies and advertising space should be handled by the campaign director, subject to the prior approval of the appropriate subsections of the citizens committee.

Before employing a campaign director, it is important to have a clear understanding of the basis of his fee. Because the fee must be decided before it is known how much money will be raised for the total campaign, it is important to work out some type of a sliding-scale fee that can be adjusted in terms of the actual amount of money

raised. It is unwise to agree to a flat fee based on an estimated budget that may never be realized. Also, it should be remembered that in placing paid advertising, the campaign director, assuming he is an advertising agent (and most of them are), will receive a commission from the media of 15 per cent of the total advertising bill; this should be considered as part of his remuneration.

Endorsements committee. Endorsement of the bond issue by civic and fraternal groups is helpful, for it indicates to the public a broad base of approval of the program. Such endorsements also offer many opportunities for publicity, particularly during the early stages of the campaign. A direct-mail approach to all organizations, requesting an endorsement and offering to appear before the group to explain the bond issue, will result in a considerable number of endorsements without further follow-up. When speakers are scheduled before such groups, the endorsement committee should follow up after the presentation to secure the endorsement.

Speakers bureau. This is certainly one of the most important committees in the bond campaign. Properly organized and trained, the speakers bureau can directly reach a large number of people in the course of the campaign. These people, in turn, will pass along the bond issue story by word of mouth to an even greater audience.

There are, however, a few basic rules that should be observed in working with a volunteer speakers bureau. It should be recognized that it is seldom practical to educate the volunteer speaker to the point where he can discuss the details of the project or is able to answer the variety of questions that will invariably be raised by the audience. Thus, the volunteer speaker should confine his remarks to broader aspects of the subject, such as the importance of the project to the community, the favorable past record of the public agency, and the necessity for approving the bond issue. Because the public agency cannot solicit for an affirmative vote, the citizens speaker must make the direct appeal to the audience. A qualified representative of the public agency should always accompany the citizens speaker to discuss the details of the project and answer questions.

In the East Bay bond campaign, there was an outstanding speakers bureau of more than 40 qualified speakers who worked with an equal number of district executives. Numerous training sessions were held, in which both the citizens speakers and the district speakers participated. During each engagement, a citizens speaker and a district speaker worked as a team. In all instances, the citizens speaker was listed on the program as the principal speaker. He opened the presentation with a 5-min background talk on the importance of water to the community and the role of the utility district in the growth and development of the community. He then introduced the district representative who explained the project with the aid of pictographs or charts. The district representative limited his remarks strictly to the presentation of the charts, which required 10 min. Following this, the citizens speaker returned to make a strong 5-min appeal for a favorable vote on the bond issue. The remaining 10 min of the 30-min presentation was opened to questions from the floor. During the campaign, such presentations were made to more than 250 organizations.

Committee of 1,000. As mentioned previously, the Committee of 1,000 was composed entirely of citizens who had endorsed the bond issue and had permitted the use of their names for advertising and publicity. This permission, incidentally, should always be secured in writing to avoid embarrassment or even legal action in the event that a person later reneges and claims that his name was used without permission.

A further suggestion for making this type of committee most effective is that it should represent the broadest possible cross section of the community, with regard to geographical area, employment, racial background, and community activity. It is a temptation to recruit the committee from the people who are known to be strong supporters of the agency, but for maximum effectiveness the broader representation is desirable.

Summary of Campaign Organization

1. The formation of a citizens committee is essential, because the public agency cannot legally campaign actively in support of the bond issue.
2. The primary function of the public agency in the campaign is to prepare the basic bond issue story and to complement the activities of the citizens committee by disseminating factual information regarding the project and the bond proposal.
3. The citizens committee must raise the money and conduct the campaign.
4. The campaign must be operated on a cash basis.
5. A paid campaign director is the best man to coordinate the activities of the citizens committee and to fill in when a volunteer is unable to perform.

Conduct of Campaign

After the planning has been done and the citizens committee organized, the campaign is ready to begin. Most bond campaigns start slowly and build up momentum as election day approaches. In the early stages of the campaign, money is scarce; campaign materials are being developed by the publicity and advertising committee, but are not yet available; paid advertising is being saved for the last few days of the campaign; and many of the detailed plans of the citizens committee are still being worked out.

Therefore, in the early stages of the campaign, heavy reliance must be placed upon newspaper publicity. In East Bay, it was found helpful to launch the campaign by holding a press conference to which the publishers of all the daily and weekly newspapers in the area (more than 40) were invited along with the representatives of radio and TV stations. It is important to make every effort to secure the attendance of publishers, station managers, and the press at such a conference.

The press conference was called approximately 4 months before the election date and prior to any public announcement of the bond issue. At the conference the entire bond proposal was explained in detail, using pictographs and offering ample opportunity for questions from the press. Complete press kits were made available, containing all possible statistical data, descriptive materials, and photographs, from which subsequent news stories and feature articles could be prepared. Press releases were also available for the smaller weeklies, which appreciate a ready-to-go story.

The publicity resulting from the press conference served as the initial announcement to the public of the

bond proposal and signaled the start of both the district and citizens committee publicity programs. In general, the district press releases throughout the campaign were concerned with the need for and the description of the bond program. The publicity of the citizens committee was concentrated on the various appointments to the committee, the endorsements received, the publicizing of the activities of the speakers bureau, and, finally, the actual appeal to the voters to approve the bond issue.

Although a press conference was chosen as the start of this campaign, there were many other approaches that might have been equally effective: town meetings, civic luncheons, chamber of commerce meetings, and a wide variety of similar affairs that focus attention on the project and start the flow of publicity.

Endorsement by Key Groups

Immediately following the initial announcement of the bond issue, it is important to appear promptly before certain key groups in the community in an effort to present the facts and secure immediate support. In the East Bay Campaign, appearances were made before a legislative delegation in Sacramento, the boards of supervisors of the two counties served, the city councils of thirteen cities, the taxpayers associations, several property owners organizations, various industrial and labor organizations, and many chambers of commerce. It is believed that many citizens look to these particular groups for advice in forming their personal opinions of a bond issue, and everything possible was done to present all the facts to such organizations as promptly as possible. Further, it was decided that their early endorsements of the bond issue, if secured, would be an excellent example of the broad community support that was essential to a successful campaign. Contact with the majority of these groups was established during the first few weeks of the campaign.

From this point on, the East Bay bond campaign can be described only as a wonderful and continuing effort on the part of hundreds of dedicated workers, both volunteer and district staffs, to bring the bond issue story to the people.

Fund raising was, as always, an arduous chore. As the money came in, more and more promotional materials were ordered. When lack of funds did not permit the purchase of materials needed, ingenious devices were worked out to obtain the same result in some other way.

Speaking engagements were solicited from every known organization in the community. Frequently, as many as twelve teams of citizen speakers and district representatives were operating in a single day. Endorsements of the program began to arrive in increasing numbers.

Publicity built up, news releases were frequent, feature articles began to appear—the first editorials were received gratefully. Slowly, the beginning of a general awareness of the bond issue came about. People were overheard talking about it. The citizens committee headquarters began to receive complaints from volunteer workers that more materials were needed and that someone's name was left out of the last press release. These complaints, within reason, are a good sign. They show that people are working on the project. The campaign was now off the ground and moving fast, but not fast enough.

Public Opinion Poll

One month before the election date another public opinion poll was conducted to determine the effectiveness of the campaign. Although the overall results of the campaign were encouraging, there were also areas of disappointment. Far too many voters were still not aware of the facts of the bond issue and thus were undecided as to how they would vote. Some geographical areas had not been covered as well as others. The hard core of about 20 per cent of the voters who, it is said, oppose every bond issue were present in this campaign.

Most significant was the fact that the public still feared that passage of the bond issue might result in an increase in taxes or water rates. Of further concern was the point, brought out by the poll, that people generally felt that even if the bonds were not passed, there was little danger of a water shortage, and they expressed confidence—or wishful thinking—that somehow the district would prevent such an occurrence.

The results of this poll spurred the citizens committee to even greater action. Particular emphasis was placed on the financing plan, and assurances were made that the bond issue would not require tax or water rate increases. Although the committee and the district were in complete agreement that it would be unwise to conduct a fear campaign based on the threat of a water shortage, nevertheless, in the light of this poll, it did become necessary to emphasize the probable consequences to the community should the bond issue fail.

It was planned that the campaign would continue to pick up speed during the last month and reach its height during the last week and particularly the last 2 or 3 days before election day. It should be mentioned here that it is most important throughout a campaign of this type to hold back the big "ammunition" for the climax and to resist the temptation for big efforts too early, although there may be a feeling that the campaign is dragging. For example, regardless of the strength of local newspaper support, there is a practical limit to how much

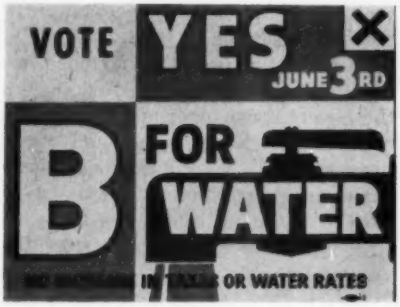

Fig. 2. "Drop-In"

Colorful "drop-ins," printed on newspaper stock, were distributed by retail stores.

space can be given to a single activity. Furthermore, press releases must have news value; one cannot keep repeating the same material. Thus, if the papers are flooded with releases and the whole story told too early in the campaign, material will run out just when the publicity is needed the most—that is, during the last few days of the campaign.

It is the same with paid advertisements. Seldom is there enough money to pay for more than a few days of concentrated ads. These are most effective immediately before the election and, therefore, should not be used too early in the campaign.

Even with the citizens committee, there is a limit to the amount of time

and effort one can expect a volunteer to give to a civic project, regardless of its merit. Therefore, this manpower should be used in such a way that it will finish strong and not be worn out in the middle of the campaign.

Promotional Materials

As the election approaches, the use of promotional materials becomes increasingly important. In general, promotional materials are used in a campaign to capture the attention of the voter and to give the agency an opportunity to solicit his vote. Therefore, the more different the types of promotional materials one can use, the better the chance of attracting the voter's attention. The material must clearly designate which ballot number or letter the voter should mark on election day.

The following are some of the promotional materials, common to most campaigns, that were used by the East Bay citizens committee:

Brochures or booklets giving the facts about the bond issue are almost essential. They can be distributed by the speakers bureau at all speaking engagements and can be used as direct-mail pieces if funds permit. They further provide an inexpensive method of answering inquiries about the bond issue.

Throw-aways and *drop-ins* are simple compositions (Fig. 2) usually printed on newspaper stock and handed out on the street or wherever large groups of people assemble. They were widely distributed by grocery, drug, and other retail stores, where clerks dropped them in each package at the cash register or checking stand. Laundries placed them in all of their bundles for several weeks before the election.

"Dear Friend" cards are postal cards that carry a brief request to vote for the bond issue; they were distributed throughout the district. Each person given 15 or 20 postals was asked to address them to an acquaintance, add his own signature, and mail them. Many volunteer groups offered to address and send out these cards, which, en masse, can be quite effective.

Chain letters are a take-off on the original chain letter idea and provide a method of placing a considerable volume of material in circulation. Like the monetary chain letters, they never work as well in practice as in theory; nevertheless, they are worth a try.

Bumper strips and window stickers are helpful and should be used in quantities depending upon the amount of money available.

Postal slugs to be used with postal metering machines are relatively inexpensive, and many large firms will agree to use them on their outgoing mail for a few weeks before the election. They are limited to a very brief message, but the message can be broadcast widely.

Quarter cards are displayed in store windows and on company bulletin boards. Provided that arrangements can be made to have these distributed at little or no cost, such cards can be helpful. Mass distribution is often expensive, however, and better results can frequently be obtained from other devices.

Billboard advertising is generally quite expensive if any significant coverage is to be obtained. A few well-placed, large boards on freeways or major streets seem more practical than extended coverage by smaller boards. Lacking the funds for regular billboards, the East Bay committee was successful in getting the approval of several factories along the freeways to use the sides of their buildings to dis-

play inexpensive oilcloth signs. Many supermarkets and other stores now use large marquee-type bulletin boards with movable letters. Arrangements were made to run "Vote Yes on 'B' for Water. June 3rd" on such bulletin boards for a few days immediately before the election.

Radio and TV spot announcements are, of course, very helpful. In metropolitan areas where the TV coverage goes far beyond the locale area of the election, the cost of TV is usually prohibitive, both because of the time charge and because the message is wasted on so many people who are not involved in the local election. This is true to a lesser extent with radio, except in those instances when the station has a truly local audience.

Bus cards and spectaculars, used on the side of buses and street cars in metropolitan areas, are very effective and relatively inexpensive in relation to the audience reached (Fig. 3). Interior bus cards are helpful, but they reach a much smaller audience.

Sound trucks coupled to traveling billboards can be used effectively to reach the more remote areas of the community (Fig. 4). The sound truck should be used primarily for musical background to attract attention, letting the traveling billboard give the message. Attempts to use the sound truck as a traveling speaker's platform do not seem to be very effective; they tend to antagonize people who resent the noise and who cannot hear the message anyway.

Fig. 3. Bus "Spectacular"

Used on buses and street cars in metropolitan areas, these signs were very effective and relatively inexpensive.

Newspaper Advertising

Newspaper advertising is very important in the last days of the campaign. Probably the principal justification for earmarking a large percentage of the campaign budget to newspaper advertising is because it represents the cheapest method of reaching the largest number of people with a message that can be completely controlled in size and content. In general, a few large ads, run on consecutive days immediately before the election, are superior to smaller ads, run more frequently throughout the campaign.

An important feature of this type of ad is the inclusion of as many names

of persons and organizations endorsing the campaign as it is possible to run within the space afforded. Copy should be limited to a few key points, with most emphasis placed on the proposition designation.

Special Activities

In discussing methods of speeding up the tempo of the campaign and focusing public attention on the bond issue during the last week or 10 days of the campaign, mention should be made of the possibility of arranging some special activity that will command community-wide attention. The special activity may be a parade, rally, or an open-house program.

The East Bay Municipal Utility District was fortunate that the 35th anniversary of its organization fell on a date less than 10 days before the election. Accordingly, an anniversary luncheon and celebration was arranged and sponsored by each of the 20 chambers of commerce and by each of the 13 cities and the 2 counties within the district.

The boards of supervisors of both counties and all the city councils passed resolutions declaring the week as "East Bay Municipal Utility District Anniversary Week," and each chamber of commerce prepared similar resolutions of congratulations and best wishes. These actions offered many possibilities to photograph the various mayors signing proclamations and resulted in a steady flow of publicity immediately prior to the luncheon. The luncheon itself drew a crowd of more than 400 civic leaders and public officials who added to the enthusiam of the campaign and sparked further publicity of the bond issue.

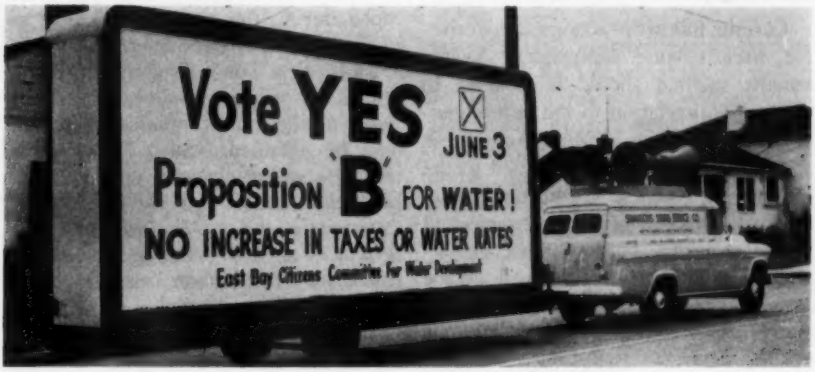

Fig. 4. Sound Truck and Traveling Billboard

These are effectively used in areas of the community where newspaper circulation is light and other forms of publicity are relatively ineffective.

Conclusion of Campaign

With this extra "shot in the arm," the campaign raced to its conclusion, and by election eve, the community had been fairly well saturated with the bond issue story. On election day, the

few remaining speaking engagements were concluded; the final advertisements were run; sound trucks and traveling billboards covered the areas of known weakness; and the decision was left to the voters.

Fortunately, the results at the polls were gratifying, for the bond issue passed by a margin of 3½ to 1, with less than 50 out of more than 2,000 precincts failing to approve it. In many areas the voting ran as high as 20 and 30 to 1 in favor.

Followup After Election

Certain followup actions are desirable after a bond campaign. A systematic method should be devised to express appreciation to the voters generally and to the citizens committees specifically, for they are entitled to the major share of the credit for a successful campaign. As a matter of good public relations, both of these groups should be kept fully informed of the progress of the project throughout the construction period. Fortunately, most construction projects provide ample opportunities for photographs and publicity. Group tours are beneficial. In the past, motion pictures have been taken of major construction projects and then made available for showing to interested groups. Bill inserts and pamphlets provide an inexpensive method of reporting to the public on the investment of funds they have authorized. Every effort should be made to maintain the close relationship with the public that was developed during the campaign.

A precinct-by-precinct review of the results of a bond issue election provides one of the best, and certainly the least costly, public opinion polls that can be obtained. Such a study will reveal areas of strength and weakness and will be helpful in guiding the operations and public relations programs of agencies starting *now* to plan for future bond issue campaigns.

Fluoridation in Major Cities of the United States

William T. Ingram and George W. Moore

A contribution to the Journal by William T. Ingram, Adjunct Prof., College of Eng., New York Univ., New York, N.Y., and George W. Moore, Chief, Water Supply Sec., Bureau of Environmental Sanitation, State Dept. of Health, Albany, N.Y. This is a condensation of a report, "Water Fluoridation Practices in Major Cities of the United States," prepared for the New York State Dept. of Health, December 1958, by the Research Div., College of Eng., New York Univ.

THERE have been a number of questions raised by water utility officials, state departments of health, research groups, and practicing engineers with respect to the engineering problems associated with fluoridation of a water supply. These questions center around: [1] the feasibility of applying the fluoride ion to large volumes of water, with effective mixing and diffusion throughout; [2] the persistence of fluoride ion residuals in systems comprising many miles of old and new distribution mains and a variety of pipe materials; and [3] the effectiveness of control of dosage and residuals within limits accepted by the medical profession as safe and established by the medical and dental professions as optimal for the prevention of dental caries.

In 1957, the New York State Department of Health requested the Research Division of the New York University College of Engineering to undertake a study of water fluoridation practices in major cities of the United States. The purpose of the study was to evaluate fluoridation practices and present recommendations to assist the state health department in advising water utilities on engineering practices associated with fluoridation.

A guide form was developed to assist in the orderly assembly of pertinent information. Twenty cities in 16 states were investigated, and conferences were held with representatives of water and health departments who were responsible for monitoring, supervising, operating, and maintaining treatment programs. Additional information on 9 cities in the San Francisco–Oakland Bay area was obtained from studies made by the California State Health Department, Bureau of Sanitary Engineering. San Juan, P.R., also practices water fluoridation, information about which was obtained by correspondence.

General Discussion

Twenty cities were studied in detail (Table 1). The largest of these is Chicago, Ill., the smallest Charlotte, N.C. The total population of the 20 cities serving fluoridated water is 18,721,220. In the United States, at the end of 1956, there were 31,416,000 people receiving water with fluoride ion from 1,487 water systems. This study, therefore, includes 59.6 per cent

of the total population of the United States receiving fluoridated water at that time.

Five of the 20 cities serve populations of 1,000,000 or more. These five represent 56.8 per cent of the population included in this study and 33.9 per cent of the population of the nation then receiving fluoridated water. Of the five, Philadelphia and Chicago are two of the five most populous cities in the United States. Six of the cities studied—Chicago, Philadelphia, Cleveland, Baltimore, Washington, and St. Louis—are among the ten most populous cities of the United States, according to the 1950 census. With the exception of Charlotte, all 20 cities have more than 300,000 people. The average population of 18 of these cities * is 988,900; the median population is 658,000.

On the basis of annual average daily demand, Chicago ranks first with 1,031.5 mgd. The average demand of 18 cities * is 174.8 mgd; the median flow is 105.1 mgd. On the basis of average per capita consumption of 18 cities,* Chicago leads with 229.8 gpcd. Providence, R.I., with 104.5 gpcd, has the least per capita consumption. The median is 154.5 gpcd.

Table 1 shows when fluoridation began in each city studied. Charlotte, the first of this group, started in April

TABLE 1

Water Service and Treatment—1956 Data

City	Population Served	Fluoridation Started	Treatment Plants			
			No.	Capacity *mgd*	Avg Amount of Water Treated* *mgd*	Treatment†
Baltimore, Md.	1,336,760	Nov. 1952	3	368	198.0	Coag S, RF, C, Fl, CCO, Fe, TO
Buffalo, N.Y.	600,000	May 1955				Coag S, RF, C, Fl
Charlotte, N.C.	185,000	Apr. 1949	1	25	19.8	Coag S, RF, C, Fl, CCO, TO, NH_3
Chicago, Ill.	4,488,000	May 1956	1‡	320	338.2	Coag S, RF, C, Fl, NH_3, CCO, TO
Cleveland, Ohio	1,600,000	Jul. 1956	3	415	323.2	Coag S, RF, C, Fl, CCO, TO
Denver, Colo.	641,000	Jun. 1954	5	252	106.5	Sed, Coag S, RF, SF, C, Fl, NH_3
Indianapolis, Ind.	530,000	Aug. 1951	2	98	65.6	Coag S, RF, C, Fl, TO, NH_3
Louisville, Ky.	550,000	Aug. 1951	1	160	81.0	Sed, Coag S, RF, C, Fl, WS, TO
Miami, Fla.	500,000	Apr. 1952	2	100	81.0	RF, C, Fl, WS, Coag S, CCO
Milwaukee, Wis.	812,700	Jul. 1953	1	200	140.4	Coag S, RF, C, Fl, TO, NH_3
Norfolk, Va.	317,500	Aug. 1952	2	48	41.0	Coag S, RF, C, Fl, CCO, TO
Philadelphia, Pa.	2,170,000	Sep. 1954	4	458	353.4	Sed, Coag S, RF, SF, C, Fl, CCO, TO, CD, O_3
Pittsburgh, Pa.	675,000	Dec. 1952	1	140	105.0	Sed, Coag S, SF, C, Fl, CCO, TO CD
Providence, R.I.	395,660	Sep. 1952	1	105	41.4	Coag S, RF, C, Fl
Rochester, N.Y.	320,000	Jul. 1952	1	36	9.6	Coag S, RF, C, Fl
St. Louis, Mo.	867,500	Sep. 1955	2	360	176.8	Sed, Coag S, RF, C, Fl, NH_3
St. Paul, Minn.	357,000	Oct. 1952	1	63	40.0	Coag S, RF, C, Fl, WS, NH_3, CCO
San Francisco, Calif.	941,100	Aug. 1952	9§		112.8	C, Fl, Pre.Sed
Toledo, Ohio	390,000	Dec. 1955	1	120	67.9	Sed, Coag S, RF, CD, NH_3, C, Fl, WS, CCO, TO
Washington, D.C.	1,044,000	Jun. 1952	2	234	160.0	Sed, Coag S, RF, CD, SF, C, Fl, CCO, TO

* Partial or total treatment of supply; not necessarily the same as water demand.

† *Key:* Coag S, coagulation and sedimentation; RF, rapid sand filtration; C, chlorination; Fl, fluoridation; CCO, corrosion control; Fe, iron removal; TO, taste and odor; WS, water softening; Sed, plain sedimentation; NH_3, ammonia-chlorine; SF, slow sand filtration; CD, chlorine dioxide; Pre.Sed, preliminary sedimentation; and O_3, ozonation.

‡ South District treatment plant. The water at Chicago's other 8 treatment plants is treated with chlorine and fluorine only.

§ Chlorination plants.

* Buffalo and Rochester are excluded.

1949. Louisville, Ky., and Indianapolis started in 1951. Nine of the twenty—Baltimore; Washington; San Francisco; Pittsburgh; Miami, Fla.; Providence, R.I.; St. Paul, Minn.; Rochester, N.Y.; and Norfolk, Va.—began fluoridating water in 1952. The practice began in Milwaukee in 1953, and in Denver and Philadelphia in 1954. St. Louis, Buffalo, and Toledo, Ohio, followed in 1955. Cleveland and Chicago began to fluoridate in 1956. Nineteen of the cities have municipally owned water utilities. Indianapolis is served by a privately owned utility.

Water Systems

These cities derive some or all of their water from surface sources, with the exception of Miami. Ground waters provide Denver with 18 per cent of its supply. The systems at Indianapolis, Milwaukee, and San Francisco depend on ground water for 1 per cent or less of their total supply.

None of the water is put into distribution without some form of treatment in addition to fluoridation (Table 1). Many of the systems have the advantage of lake storage, or storage in large-capacity raw-water reservoirs. This stored water is at least chlorinated before distribution. In combination, the 20 systems provide all the usual types of treatment:

Type of Treatment	No. Systems
Primary sedimentation	7
Chemical coagulation and sedimentation	19
Rapid sand filtration	18
Slow sand filtration	4
Softening	4
Corrosion control	11
Iron removal	1
Taste and odor control	12
Chlorination	20
Chlorination plus ammonia	8
Chlorine dioxide	4
Ozonation	1

TABLE 2

Water Demands

City	Percentage of Annual Avg Daily Demand		Annual Avg *mgd*
	Winter	Summer	
Baltimore, Md.	96.5	105	199.6
Buffalo, N.Y.			130.0
Charlotte, N.C.	89.8	114	19.8*
Chicago, Ill.	91.5	112.5	1,031.5
Cleveland, Ohio	88.7	116	323.2†
Denver, Colo.	63	151	105.2
Indianapolis, Ind.	92.8	108.2	63.4
Louisville, Ky.	91.6	103.3	82.0
Miami, Fla.	101.5	98.8	80.0
Milwaukee, Wis.	81.6	117.1	140.4
Norfolk, Va.	94.9	110.7	41.3
Philadelphia, Pa.	99.0	101.8	351.7
Pittsburgh, Pa.			105.0
Providence, R.I.	93.2	108.7	41.4
Rochester, N.Y.			42.0
St. Louis, Mo.	88.8	122.1	181.5
St. Paul, Minn.	80.8	120	40.0†
San Francisco, Calif.			91.3‡
Toledo, Ohio	94.5	115.6	63.4
Washington, D.C.			153.2§

* 1957 data.
† 1955 data.
‡ Direct service to city and northern San Mateo County.
§ Demand for city only.

Several of the cities have more than one treatment plant (Table 1). Denver has five, Philadelphia has four, Cleveland and Baltimore each have three. San Francisco has 9 chlorination stations; Chicago has eight, as well as the South Side treatment plant. There are 11 systems that do not need to operate treatment plants at full capacity to meet maximum demands. The other nine systems find it necessary to do so every so often.

As one might anticipate, seasonal demands show greater divergence in colder climates. Table 2 analyzes the

demands on the various systems in percentage of the annual average daily demand. The larger systems—Chicago, Milwaukee, and St. Louis, for example—have winter demands approximately 90 per cent or less of the annual average. Denver has a winter demand of 63 per cent and a minimum monthly average of 62 per cent. This city shows the extreme summer demand of 151 per cent, a maximum monthly demand of 171 per cent, a maximum daily demand of 206 per cent, and a peak hourly demand of 468 per cent. The Miami system demonstrates the effect of increased winter population. The winter demand is 101.5 per cent of the annual average; the summer demand is 98.8 per cent. Baltimore and Philadelphia are affected by industrial demand as well as milder climate. The winter demands are over 95 per cent of the annual; the summer demands do not exceed 105 per cent.

The characteristics of the distribution systems are shown in Table 3. Water stored for distribution may be on the line or may pass through reservoirs before flowing into the area mains, depending on the system. Variations in methods of inventory make it difficult to compare piping materials and sizes; however, some data from the cities are shown. Pipe materials for mains include cast iron, concrete-lined cast iron, steel, lined

TABLE 3

Characteristics of Distribution Systems

City	Pipe Diameter Range *in.*	Pipe Materials*	Estimated Time of Water Delivery After Fluoridation	
			Maximum *days*	Minimum *hr*
Baltimore, Md.	6–84	CI, CLCI, C	1.4	0.4
Charlotte, N.C.	6–42	C, CLCI	8	10
Chicago, Ill.	1–54	CI, C, S	1	0.2
Cleveland, Ohio			1+	46
Denver, Colo.	1–48	CI, C, S, GI, Pb	2.4	1
Indianapolis, Ind.	6–36+	CI, CLCI, C, S	1.3	0.03
Louisville, Ky.	6–60	CI, C	2+	7
Miami, Fla.	6–51	CI, AC, S		0.2
Milwaukee, Wis.	2–54	CI	2+	2.5+
Norfolk, Va.	6–36	CI	0.4	10
Philadelphia, Pa.	3–93	CI, CLCI, C, S, SL	3	0.5
Pittsburgh, Pa.	6–36+	CI, C, S		
Providence, R.I.	6–66	CI, C, AC, rock		4
Rochester, N.Y.			5	0.2
St. Louis, Mo.	6–62	CI, CLCI, S	1.2+	14+
St. Paul, Minn.	4–42	CI, CLCI, C, S		0.08
San Francisco, Calif.	6–33	CI, SL, S	0.02+	0.1
Toledo, Ohio	6–72	CI, CLCI, C, SL, CI (enamel)	5+	0.03
Washington, D.C.	6–78	CI, CLCI, C, S, AC	5+	1

* *Key:* CI, cast iron; CLCI, concrete-lined cast iron; C, concrete; S, steel; SL, steel lined with concrete or coal-tar enamel; AC, asbestos cement; Pb, lead; and GI, galvanized iron.

mains, depending on the system. Variations in methods of inventory make it difficult to compare piping materials and sizes; however, some data from the cities are shown. Pipe materials for mains include cast iron, concrete-lined cast iron, steel, lined

steel, concrete, and asbestos-cement. The Chicago system has over 4,000 mi of lines, Baltimore over 2,000, and Charlotte only 636. General storage in distribution varies from 12 mil gal in Charlotte to 2,960 mil gal in San Francisco. Distance along distribution routes varies from 11 mi in Indianapolis and St. Paul to 35 mi in Rochester. Time of delivery after fluoridation is extremely variable but may take up to 8 days (as in Charlotte) or 19 hr (as in Norfolk) for distant consumers. Nearby consumers, of course, may receive fluoridated water in a matter of minutes, as in Chicago, Miami, Rochester, St. Paul, and Toledo.

Temperatures of water in the several systems are dependent to a large extent on the characteristics of the system. Temperatures for January, July, and for the year are shown in Table 4. These figures also reflect the climate of the location of the system. Miami, for example, has practically no variation in temperature of its well supply. St. Paul, St. Louis, and Washington reflect river water variations. The range of temperature for all cities is 32°–90°F, with an annual average variation of 47.5°–77°F.

Pressures in distribution systems are a result of localized conditions, design, and operations. Some cities have as

TABLE 4

Average Water Temperatures in City Systems

City	Temperatures—°F								
	January			July			Annual		
	Min.	Max.	Avg	Min.	Max.	Avg	Min.	Max.	Avg
Baltimore, Md.	37	50	42.5	48	70	62	37	75	54.2
Charlotte, N.C.	43	51	48	81	86	84	48	84	66
Chicago, Ill.	32	32	32	62	72	67.2	32	72	47.5
Cleveland, Ohio	32	33	33	55	72	67	32	76	55
Denver, Colo.									
Moffat	48	55	51.5	60	65	62.5	47	62.5	
South Platte	46	49	47.5	60	62	61	45.5	70.0	
Indianapolis, Ind.	33	39	35	72	82	77	33	82	77
Louisville, Ky.	34	40	40	81	86	85	34	40	61.5
Miami, Fla.			74			75			75
Milwaukee, Wis.	42	45	44	54	59	57	40	63	50
Norfolk, Va.	46	51	48.5	77.5	81	80	47	80	65
Philadelphia, Pa.	33	40	36	74	82	77	35	82	
Pittsburgh, Pa.									
Providence, R.I.	41	45	43	68	70	70	41	70	57
Rochester, N.Y.							34	70	60
St. Louis, Mo.	38	42	39	80	90	85	39	86	62
St. Paul, Minn.	35	35	35	72	81	77	35	79	54
San Francisco, Calif.									
Crystal Springs	48	51		63	65		48	67	58.9
San Andres	46	50		62	63		46	66	58
Toledo, Ohio	35	35	35	71	75	73	35	75	51.5
Washington, D.C.	32	51	40	70	80	74			

many as 11 pressure zones; others have only one. Pressures may range up to 235 psi.

It may be concluded from the foregoing that there are few variants in water systems that are not present in the 20 systems studied.

delphia's Delaware supply has 0.07 ppm iron and manganese. Pittsburgh's Allegheny River supply has 0.1 ppm iron and 0.11 ppm manganese. The calcium range among 22 supplies is *7.2–77.7* ppm, with the White River supply in Indianapolis having the high

TABLE 5

Chemical Analyses of Treated Water Supplies

City	pH	Concentration—*ppm*									
		Alkalinity	Fe	Ca	Mg	Na & K	Mn	HCO_3	Cl	F	Hardness
Baltimore, Md.	7.9	42	0.01	16.6	4.0	3.2	0.0	51	6.9	0.99	57
Charlotte, N.C.	7.6		0.0	7.2	1.1	4.0	0.01	24	2.7	1.0	23
Chicago, Ill.											
South District	7.8	115	0.015	35.9	9.0	5.1	0.0	114	7.1	0.79	127
Central & N. District	8.3	112.1	0.025	34.5	10.0	4.5	0.0	106	5.7	0.56	127
Cleveland, Ohio	7.6	88	0.01	35	8.2				22		123
Denver, Colo.											
S. Platte source				29.2	10.5	27.6		88.5	42.0	0.76	113.6
Moffat source				12.8	2.4	2.6		37.4	0.52	0.92	42.1
Indianapolis, Ind.											
Fall Creek	7.47	177	0.02	58	23.4	10.9			13	0.89	240.4
White River	7.46	218	0.04	77.7	27.2	19.6			25	0.90	306
Louisville, Ky.	7.9	55	0.0	38.7	8.4				28.6	0.99	128
Miami, Fla.											
Hialeah	8.5	43	0.0	23	5.1	14			32		78
Alexander Orr	8.8	58	0.02	24	3.1	7.0			12		73
Milwaukee, Wis.	7.61		0.004	34.8	11.0	6.3		102	7.3		132
Norfolk, Va.	8.5	32								0.9	
Philadelphia, Pa.											
Schuylkill source	6.7	33	0.056				0.04		13		134
Delaware River source	6.4	22	0.07				0.07		11		58
Pittsburgh, Pa.	6.5	5	0.1	21.4	4.6	6.3	0.11	6	18	0.85	80
Providence, R.I.	9.5	15.7	0.01				0.0			0.16	28
St. Louis, Mo.											
Mississippi River	9.06	47.0		22.4	14.0	51.2		28.9	26.5	0.91	113
Missouri River	9.15	45.0		23.5	14.2	55.6		26.2	24.5	0.94	117.0
St. Paul, Minn.	8.6	92	trace	28.4	11.1	4.7			10.1	0.64	121
San Francisco, Calif.											
Crystal Springs	7.3	32.4	0.04	11.1	3.0	5.8	0.004	39.6	7.6	0.9	40.3
San Andres	7.6	45.5	0.02	13.8	14.6	8.6	0.004	55.3	10.1	1.0	53.8
Toledo, Ohio	9.0			27.1	6.9	9.5			20.1	1.08	90
Washington, D.C.											
Dalecarlia	7.6	59	0.02	32.4	6.7		0.0	72	7.6		108
McMillan	7.5	56	0.03	31.0	6.2		0.0	68	6.5		102

Water Characteristics

Table 5 compares the chemical composition of the treated waters. The pH range is 6.4–9.15. Of 24 supplies, four have pH values less than 7.0; twelve have 7.0–8.0; and eight have values greater than 8.0.

The alkalinity range of 21 supplies is 5–218 ppm. Iron and manganese in treated waters are negligible. Phila-

value. The chloride range is 0.5–42.0 ppm, both extremes being found in Denver.

The range of hardness (as $CaCO_3$) in 25 supplies is 23–306 ppm. Fourteen supplies have more than 100 ppm calcium carbonate. The bicarbonate range is 6–114 ppm in 14 supplies reported. The range of sodium and potassium combined is 2.6–55.6 ppm in

18 supplies reported: three have 4.0 or less; seven have 4.1–8.0; three have 8.1–12.0; two have 12.1–24.0; and three have more than 24 ppm.

Fluoride ion was present in all supplies reported.

Fluoridation Equipment and Chemicals

Table 6 contains data on fluoridation stations, fluoride ion in source water, the chemicals and dosages used, and the average fluoride ion in treated water, reported by the 20 cities. The averages are not in relation to one another, as they are not based on concurrent sampling. Nor are they necessarily reconciled with respect to total source residual plus dosage.

In the 20 cities there are 37 fluoridation stations in which are located 46 feeder units (Table 7). Chicago has 3 stations with 6 feeder units; Philadelphia, 5 stations with 7 units; and San Francisco, 3 stations with 4 units. Few stations have duplicate equipment; feeding is stopped while unit repairs are being made. It is generally understood that decreased fluorides in the system for a short period of time are of no consequence. Great care is exercised to prevent overdosage. It is apparent from the operations studied that the chemical feeders can maintain dosage within much closer limits of accuracy than specified by the manufacturers of the equipment.

The chemical specifications followed are essentially those recommended by AWWA (*1–3*). The quantities of fluoride-bearing chemicals used in each of the cities in 1950–56 are shown in Table 8. The chemicals consumed in 1956 included 3,957 tons of hydrofluosilicic acid, 459 tons of sodium fluoride, and 2,614 tons of sodium silicofluoride. In 1956, 4 cities were using the acid, four were using sodium fluoride, and twelve were using sodium silicofluoride. In 1957, St. Paul changed from sodium fluoride to acid, and Toledo changed from sodium fluoride to sodium silicofluoride. Among the 20 cities, only Charlotte and Norfolk were using sodium fluoride in 1957. Charlotte provided an alternate bid specification for sodium silicofluoride for 1958.

Cost Estimates

A summary of fluoridation costs in 18 cities is given in Table 9. Chicago has spent $382,040 on construction of facilities, more than any of the other cities. The amortized annual cost has been estimated at $32,003 per year. Cleveland has the next highest cost of construction, $116,082, which reduces to an annual cost of $9,724. Philadelphia, San Francisco, and Washington follow in that order. Chicago has the highest annual operating cost—$370,355, which includes $288,770 for chemicals and $81,585 for maintenance and operations. Chicago is also the biggest user of water and has the largest population served. Its total fluoridation costs amount to 8.9 cents per capita or $1.07 per million gallons of water served.

More than half of Denver's water contains fluorides naturally; hence, the total annual cost is low at $0.30 per million gallons or 1.8 cents per capita. If the charges are computed on the amount of water to which fluoride chemicals were added in 1956, that charge would be $0.80 per million gallons or 4.8 cents per capita.

TABLE 6

*Average Fluoride Ion Content in Source and Treated Waters**

City & Plant	Avg F^- Content in Source Water *ppm*	Chemical	Avg F^- Dosage *ppm*	Avg F^- Content in Treated Water *ppm*
Baltimore, Md.				
Montebello	0.11	H_2SiF_6	1.18	0.99
Ashburton	0.0	H_2SiF_6	1.18	0.83
Buffalo, N.Y.				
Colonel Ward		Na_2SiF_6		
Charlotte, N.C.				
Vest Station	0.05	NaF	0.95	1.00
Chicago, Ill.				
South District	0.12	H_2SiF_6	0.85	0.93
Central Zone	0.11	H_2SiF_6	0.56	0.68
North Zone	0.10	H_2SiF_6	0.58	0.68
Cleveland, Ohio				
Nottingham	0.10	Na_2SiF_6	0.90	0.98
Baldwin		Na_2SiF_6		
Division		Na_2SiF_6		
Denver, Colo.				
Moffat	0.10	Na_2SiF_6	0.9	0.9
Indianapolis, Ind.				
Fall Creek	0.20	Na_2SiF_6	1.0	0.94
White River	0.20	Na_2SiF_6	1.0	0.99
Louisville, Ky.				
Louisville Treatment Plant	0.20†	Na_2SiF_6	1.0	0.99
Miami, Fla.				
A. Orr Jr.	0.16	Na_2SiF_6	0.9	0.8–1.0
Milwaukee, Wis.				
Treatment Plant	0.09	Na_2SiF_6		0.9–1.0
Norfolk, Va.				
Moores Bridges	trace	NaF	1.0	0.9
37 St. Filter Plant	trace	NaF	1.0	0.9
Philadelphia, Pa.				
Queen Lane North	0.25	H_2SiF_6	0.87	1.02
Queen Lane South	0.25	H_2SiF_6	0.87	0.94
Torresdale	0.18	H_2SiF_6	1.02	1.11
Upper Roxborough	0.20	H_2SiF_6	0.93	1.04
Lower Roxborough	0.20	H_2SiF_6	0.83	1.04
Belmont	0.15	H_2SiF_6	1.05	1.07
	0.15	H_2SiF_6		1.09
Pittsburgh, Pa.				
Aspinwall	0.40	Na_2SiF_6	0.62	1.0
Providence, R.I.				
Providence Treatment Plant	0.22	Na_2SiF_6	1.00	1.06
Rochester, N.Y.				
Hemlock	0.00	Na_2SiF_6	1.0	1.0
Lake	0.10	Na_2SiF_6	0.93	1.3†
St. Louis, Mo.				
Chain of Rocks	0.40	H_2SiF_6	0.55	0.92
Howard Bend	0.49	H_2SiF_6	0.05	0.93

* Averages are not compiled on a concurrent sampling basis and are not necessarily reconciled as to total source residual plus dosage.
† Maximum.

TABLE 6—*Average Fluoride Ion Content (contd.)*

City & Plant	Avg F^- Content in Source Water *ppm*	Chemical	Avg F^- Dosage *ppm*	Avg F^- Content in Treated Water *ppm*
St. Paul, Minn.				
St. Paul Treatment Plant	0.1	H_2SiF_6	0.9	1.0
San Francisco, Calif.				
Crystal Springs	0.05	Na_2SiF_6	0.85	0.90
San Andres 1	0.05	Na_2SiF_6	0.76	0.81
San Andres 2	0.05	Na_2SiF_6	0.72	0.77
Toledo, Ohio				
Collins Park	0.0+	Na_2SiF_6	0.93	0.98
Washington, D.C.				
Dalecarlia	0.25	Na_2SiF_6	0.98	1.01
McMillan	0.25	Na_2SiF_6	1.09	1.01

In Fig. 1 and 2, 18 cities are ranged according to annual fluoridation cost per million gallons and annual fluoridation cost per capita, respectively. It will be observed that Charlotte has the highest cost per million gallons and is second only to Cleveland in annual cost per capita. The respective unit costs in Charlotte are $2.87 per million gallons and 11.2 cents per capita per year. The average 1956 cost of water fluoridation in the 18 cities was $1.23 per million gallons or 7.9 cents per capita. In terms of cost per million gallons, San Francisco and Providence are median cities, with $1.32 and $1.16, respectively. Pittsburgh and Toledo are median cities with respect to annual per capita cost, with 7.7 cents and 6.7 cents, respectively.

Eight of the cities studied—Chicago, Philadelphia, Cleveland, Baltimore, San Francisco, Washington, Milwaukee, and St. Louis—serve more than 800,000 people. The average cost per million gallons of these eight is $1.22, which is within a cent of the average of 18 cities. The per capita average among the 8 cities is 8.4 cents, which is half a cent per capita higher than the average of 18 cities. Four of the 8 cities—Chicago, Philadelphia, Baltimore, and St. Louis—use hydrofluosilicic acid as a source of fluoride ion. Four use sodium silicofluoride. Data of the average unit costs of each of these groups and data for all 18 cities show that there are apparent advantages in using hydrofluosilicic acid. Acid application costs 8.0 cents per capita per year, as compared with 9.2 cents per capita per year for sodium silicofluoride (a 15 per cent increase in cost). A more accurate comparison is observed in the production cost of fluoridated water, which is $1.10 per million gallons for those cities using acid and $1.51 for those using sodium silicofluoride, or a 37.3 per cent increase when sodium silicofluoride is used. Thus, the annual costs for cities using the acid have markedly lowered the average costs of all 18 cities. The significant difference is in the costs of the chemicals. Sodium silicofluoride as a source of fluoride ion is 46.6 per cent more costly per million gallons of water treated than the acid.

The range of production costs among 18 cities is $0.30–$2.87 per million gallons; the range of per capita cost is 1.8–12.6 cents per capita per year. Among 8 cities with more than 800,000 people, the corresponding

TABLE 7

*Fluoridation Chemicals and Equipment**

City	Chemical	Amount Used *tons*	No. of Stations	No. of Feeder Units	Type of Feeder	Point of Fluoride Application
Baltimore, Md.	H_2SiF_6	1,450.5	2	2	liquid acid	filtered water before lime addition
Buffalo, N.Y.	Na_2SiF_6		1	1	gravimetric dry	
Charlotte, N.C.	NaF	63.0	1	1	gravimetric dry	filter effluent
Chicago, Ill.	H_2SiF_6	1,418.1	3	6	liquid acid	conduit ahead of pump station, rapid-mix chamber
Cleveland, Ohio	Na_2SiF_6	710.0	3	3	gravimetric dry	filter influent conduit, filter effluent
Denver, Colo.	Na_2SiF_6	59.0	1	2	gravimetric dry	filter effluent
Indianapolis, Ind.	Na_2SiF_6	134.1	2	2	gravimetric dry	filtered water
Louisville, Ky.	Na_2SiF_6	204.0	1	1	gravimetric dry	filtered water
Miami, Fla.	Na_2SiF_6	98.6	2	2	gravimetric dry	before filtration (after recarbonation)
Milwaukee, Wis.	Na_2SiF_6	281.0	1	1	gravimetric dry	filtered water
Norfolk, Va.	NaF	112.5	2	2	gravimetric dry	filtered water
Philadelphia, Pa.	H_2SiF_6	520.3	5	7	liquid acid	filtered water
Pittsburgh, Pa.	Na_2SiF_6	242	1	2	gravimetric dry	influent to sedimentation basins
Providence, R.I.	Na_2SiF_6	102.4	1	1	gravimetric dry	filtered water
Rochester, N.Y.	Na_2SiF_6	95.2	2	2	gravimetric dry	filtered water, head of transmission conduit
St. Louis, Mo.	H_2SiF_6	676.5	2	2	liquid acid	filtered water
St. Paul, Minn.	H_2SiF_6	80	1	1	liquid acid	before filtration (after carbonation)
San Francisco, Calif.	Na_2SiF_6	221.6	3	4	gravimetric dry	conduit transmission lines
Toledo, Ohio	NaF	209.0	1	2	gravimetric dry	filtered water
Washington, D.C.	Na_2SiF_6	450	2	2	gravimetric dry	filtered water, before coagulation

* 1956 data for all cities listed, except for Charlotte, Cleveland, St. Louis, and San Francisco, for which the data pertain to 1956–57.

TABLE 8

Quantity of Fluoride-Bearing Chemical Used

City	Chemical	Amount for Annual or Fiscal Year—*tons*						
		1950	1951	1952	1953	1954	1955	1956
Baltimore, Md.	H_2SiF_6				1,420	1,436	1,327	1,450
Buffalo, N.Y.	Na_2SiF_6							
Charlotte, N.C.	NaF	36	0	0	52	59	56	63
	Na_2SiF_6	7	34	35	37	7	0	0
Chicago, Ill.	H_2SiF_6							1,418*
Cleveland, Ohio	Na_2SiF_6							719
Denver, Colo.	Na_2SiF_6					11	36	59
Indianapolis, Ind.	NaF		61	108				
	Na_2SiF_6			34	115	102	104	134
Louisville, Ky.	Na_2SiF_6		61	141	146	146	161	204
Miami, Fla.	Na_2SiF_6			48	72	68	94	105
Milwaukee, Wis.	Na_2SiF_6				142*	288	276	281
Norfolk, Va.	NaF			17	47	44	108	112
Philadelphia, Pa.	H_2SiF_6					160	537	577
Pittsburgh, Pa.	Na_2SiF_6				175	247	259	242
Providence, R.I.	Na_2SiF_6			8	104	94	101	102
Rochester, N.Y.	Na_2SiF_6							96
St. Louis, Mo.	H_2SiF_6						201	512
St. Paul, Minn.	NaF						20*	75*
	Na_2SiF_6			21*	86	94	65*	
San Francisco, Calif.	Na_2SiF_6			76	91	80	179	222
Toledo, Ohio	NaF							209
Washington, D.C.	Na_2SiF_6				513	480	450	450

* Datum for part of the year.

ranges are \$0.71–\$1.85 per million gallons and 5.2–12.6 cents per capita per year.

Fluoride Ion Residuals

Because of the diversity of operating conditions and the wide variations in flow distance and period of flow, it is possible in only a few instances to relate the fluoride ion residual in the distribution system to the actual dosage that would be expected to provide that residual at the time of sampling (Table 6). With respect to the residuals found in the 20 city systems, it is helpful to realize that detention times before fluoride enters the system range from 0 to 146 hr. The time of mixing is not always determinate, as the chemical is mixed in various ways, depending on the plant flow plan. Among 22 treatment plants where an estimate of mixing time had been made, the range was from less than 1 min to 120 min (Table 10).

Employee Health

Indianapolis and Washington have conducted exhaustive medical studies of personnel handling fluorides. These studies show that there is no exposure effect that cannot be guarded against with accepted industrial hygiene practices. Workmen wear protective clothing while handling the chemicals, and ventilation systems are provided at places where chemicals are stored and transferred.

Chemical-Handling Problems

Treatment plant personnel in all cities agree that the problems of handling fluorides are generally not different from those encountered in the handling of other water treatment chemicals. The usual problems encountered include:

1. Clogging, arching, and blocking of dry feeders, if the chemical salt is too powdered
2. Balling and blocking, if the chemical is damp
3. Overrunning the proportioning mechanism, if the material is too free flowing
4. Incrustation of chemical solution feed pipes, if the solution is near saturation

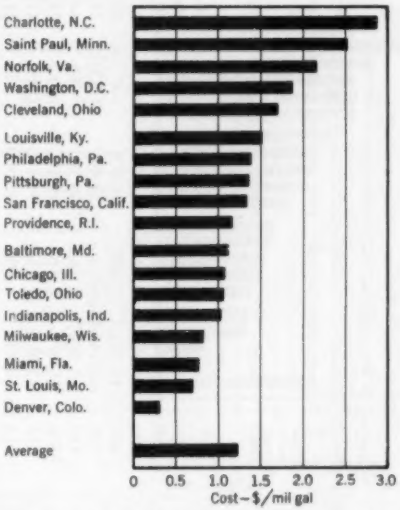

Fig. 1. Annual Fluoridation Costs per Million Gallons

San Francisco and Providence are the median cities, with \$1.32 and \$1.16, respectively.

5. Closure of opening in diffusion tubes or dispersion tubes by incrustation.

No unusual corrosion problems have occurred that may be called peculiar to the handling of fluoride chemicals. Corrosion-resistant materials, such as stainless steel and plastic, are used for safety in the handling of fluoride solutions.

TABLE 9

Summary of Fluoridation Costs, 18 Cities

City	Chemical	Demand *mgd*	Population Served *1,000*	Construction Cost—$		1956 Operating Cost Estimate—$			Annual Cost		
				Total	Annual	Chemical	Operation & Maintenance*	Total	Total $	$/mil gal	$/cap.
Baltimore, Md.	H_2SiF_6	199.6	1,337	11,385	954	80,000	500	80,500	81,454	1.13	0.061
Charlotte, N.C.	NaF	19.8	185	3,600	360	17,910	2,500	20,410	20,770	2.87	0.112
Chicago, Ill.	H_2SiF_6	1,031.5	4,488	382,040	32,003	288,770	81,585	370,355	402,358	1.07	0.089
Cleveland, Ohio	Na_2SiF_6	323.2	1,600	116,082	9,724	191,706	—	191,706	201,430	1.71	0.126
Denver, Colo.	Na_2SiF_6†	105.2	641	13,621	695	10,955	—	10,955	11,650	0.30	0.018
Indianapolis, Ind.	Na_2SiF_6	63.4	530	used existing equip.		21,400	3,500	24,900	24,900	1.04	0.047
Louisville, Ky.	Na_2SiF_6	82.0	550	4,880‡	488	43,707	509	44,216	44,704	1.51	0.081
Miami, Fla.	Na_2SiF_6	80.0	500	16,879	1,519	19,109	1,911	21,020	22,539	0.77	0.045
Milwaukee, Wis.	Na_2SiF_6	140.4	813	22,667	431	39,878	2,000	41,878	42,309	0.83	0.052
Norfolk, Va.	NaF	41.3	317	8,000	800	31,500	250	31,750	32,550	2.16	0.103
Philadelphia, Pa.	H_2SiF_6	351.7	2,170	82,030	6,450	165,228	8,000	173,228	179,678	1.40	0.083
Pittsburgh, Pa.	Na_2SiF_6	105.0	675	7,200	603	37,700	13,919	51,619	52,222	1.36	0.077
Providence, R.I.	Na_2SiF_6	41.4	396	19,999	1,675	15,891	—	15,891	17,566	1.16	0.044
St. Louis, Mo.	H_2SiF_6	181.5	867	28,631	1,432	43,956	1,785	45,741	47,173	0.71	0.054
St. Paul, Minn.	H_2SiF_6	40	357	8,000	670	36,100	—	36,100	36,770	2.52	0.103
San Francisco, Calif.	Na_2SiF_6	112.8	941	77,960	3,978	41,732	8,768	50,500	54,478	1.32	0.058
Toledo, Ohio	Na_2SiF_6, NaF	68.0	390	13,074	773	25,350	150	25,500	26,273	1.06	0.067
Washington, D.C.	Na_2SiF_6	160.0	1,044	60,000	3,960	82,000	22,000	104,000	107,960	1.85	0.103
Totals		3,146.8	17,801	876,048	66,515	1,192,892	147,377	1,340,269	1,406,784		
Avg		174.8	988.9	48,669	3,695	66,272	8,188	74,465	78,155	1.23	0.079
Cost per capita				0.049	0.0037	0.067		0.075	0.0788		
Cost per million gallons				0.763	0.058	1.04		1.167	1.225		

* Dashes indicate that maintenance charges are included in overall treatment plant operations; no additional charge for fluoridation.
† More than half (65 mgd) of the water used by Denver needs no chemical addition, because the fluoride residual occurring naturally in source water is sufficient.
‡ For alteration of existing equipment.

Observations and Recommendations

As a result of these investigations, it is recommended that the following be considered by engineers concerned with water fluoridation:

1. Chemicals that meet present specifications for fluoridation have variable flow characteristics. Further study of the physical qualities of dry chemical may yield a specification for a material that will have uniform flow characteristics regardless of where it may be produced.

2. Analytical methods now used for the study of fluoride entrapped in incrustation and coatings are variable and give variable results. Further investigation of laboratory methods of recovering fluoride ion from solids is warranted.

3. Data indicate a removal of fluoride ion from water passing through sand filters. Controlled research studies on the mechanism of removal may provide information useful to all plants where it seems more practical to add the chemical before filtration. It would seem desirable, however, to avoid the practice of prefiltration fluoridation wherever possible.

4. In those cities where the persistence of fluoride ion residual was studied, results indicate that stability of residual is to be expected. It is desirable that either the city water department or health department establish a method of sampling that will provide a profile of system fluoride ion residuals related to the operations of the system. Field studies to establish accurate information on distance and period of flow to selected sampling stations would help insure the accuracy of dosage control under all conditions of system operation. Such practice should eliminate any doubts with respect to feedback of fluoride ion into the waters of a system.

5. Results of analyses of the Denver water system strongly support the indication that naturally occurring fluoride and artificially added fluoride both persist in a system in similar ways. Comparable analyses should be made in other cities with both natural and artificially added fluoride ion in water, to aid in establishing the similarities more completely.

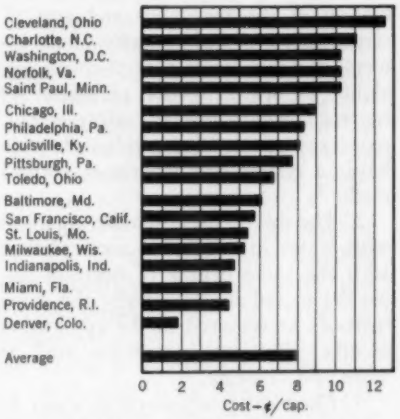

Fig. 2. Annual Fluoridation Costs per Capita

Pittsburgh and Toledo are the median cities, with 7.7 cents and 6.7 cents, respectively.

6. There was some indication that incrustation was less of a problem when the fluoride salt was mixed with water and placed in weak solution rather than in a solution approaching saturation. Laboratory investigations may be helpful in establishing an optimum or an upper limit of solution concentration that would reduce or eliminate the deposition of calcium fluoride on walls of solution feed pipes and diffusion units. Until more complete

data are established, it is suggested that solution concentrations of sodium fluoride or sodium silicofluoride be held to a maximum of 0.25 per cent in new feeder equipment.

The following comments relative to water fluoridation practices in the United States are believed to be justified generally and have been substantiated specifically in the cities studied:

1. All engineering problems that occur in the handling of fluorides can be adequately solved after due consideration of the feasibility and cost of structures, cost and capacity of equipment, cost and availability of chemicals, ability of water works personnel to control chemical dosage, safety of employees, persistence of residual fluoride ion in a system, and laboratory control methods.

2. The mixing of a fluoride chemical with water in volume is accomplished with the same degree of operator supervision and by essentially the same methods as required in the application of other chemicals in solution, such as alum and chlorine.

3. Chemical composition of water to which fluoride-bearing chemical is added is not apparently an important factor to be considered when placing fluoride into solution. Waters having a calcium content are more likely to produce a coating of calcium fluoride on solution feed lines, but laboratory supervision and operation and maintenance of the chemical application system are adequate to control dosage. In practice, the exact concentration of the chemical solution is of less importance than the routine checks of the total weight of the chemical used. In no instance do long periods of overdosage occur. The maximum plant effluent fluoride content found in this study

TABLE 10

Application of Fluoride Chemicals

City & Plant	Chemical	Avg Mixing Time *min*	Avg Detention Time* *min*
Baltimore, Md.			
Montebello	H_2SiF_6		210
Ashburton	H_2SiF_6		4,320
Buffalo, N.Y.			
Colonel Ward	Na_2SiF_6		
Charlotte, N.C.			
Vest Sta.	NaF, Na_2SiF_6	0.10	14
Chicago, Ill.			
South District	H_2SiF_6	47	510
Central Zone	H_2SiF_6		0†
North Zone	H_2SiF_6		0†
Cleveland, Ohio			
Nottingham	Na_2SiF_6	6	240+
Baldwin	Na_2SiF_6		1,440
Division	Na_2SiF_6		240+
Denver, Colo.			
Moffat	Na_2SiF_6	8	540
Indianapolis, Ind.			
Fall Creek	NaF, Na_2SiF_6		420
White River	NaF, Na_2SiF_6		60
Louisville, Ky.			
Louisville Treatment Plant	Na_2SiF_6		360
Miami, Fla.			
Hialeah	Na_2SiF_6	20	36
A. Orr Jr.	Na_2SiF_6		250
Milwaukee, Wis.			
Milwaukee Treatment Plant	Na_2SiF_6	3	90
Norfolk, Va.			
Moores Bridges	NaF	5	360
37th St. Filter Plant	NaF	5	360
Philadelphia, Pa.			
Queen Lane	H_2SiF_6		600
			15
Torresdale	H_2SiF_6		360
Upper Roxborough	H_2SiF_6		720
Lower Roxborough	H_2SiF_6		600
Belmont	H_2SiF_6	5	540
	H_2SiF_6	5	1,260
Pittsburgh, Pa.			
Aspinwall	Na_2SiF_6		2,880
Providence, R.I.			
Providence Treatment Plant	Na_2SiF_6	30	270
Rochester, N.Y.			
Hemlock	Na_2SiF_6	1	8,760
Lake	Na_2SiF_6	1	175
St. Louis, Mo.			
Chain of Rocks	H_2SiF_6	120	840
Howard Bend	H_2SiF_6	3	300
St. Paul, Minn.			
St. Paul Treatment Plant	NaF, Na_2SiF_6	2	55
San Francisco, Calif.			
Crystal Springs	Na_2SiF_6	6	430
San Andres 1	Na_2SiF_6	6	660
San Andres 2	Na_2SiF_6	13	360
Toledo, Ohio			
Collins Park	NaF	20	30
Washington, D.C.			
Dalecarlia	Na_2SiF_6	3	1,080
McMillan	Na_2SiF_6	76	4,320

* Before entering system.

† Fluoride added to central pump station serving distribution system.

(2.07 ppm) was reported in just one city, and for merely a portion of a day.

4. Neither the length of line, period of flow, age of pipe, nor materials to which water is exposed affect significantly the average fluoride ion content in distribution systems. Special studies of fluoride ion residual along routes of flow have shown only those variations that might be anticipated as the result of accepted practices and those within the reasonable limits of error of sample collection and analysis. In no instance is any pipeline corrosion traceable to the fluoride content reported.

5. This study shows no evidence of feedback of concentrations of fluoride ion from such postulated sources as pipe coatings, tuberculation, treatment sludges, and storage-reservoir sediments. On the contrary, the study shows that to achieve undesirable fluoride ion concentrations from such additions would require suspensions of the coating, sludge, or rust in quantities so great as to render the water nonpotable and unfit for use. In one example of hydrant flushings with water clearly unacceptable for normal use, the maximum fluoride ion content of the supernatant liquor was 1.32 ppm below the maximum suggested by USPHS.

6. The annual cost of fluoridation in cities with more than 300,000 people may be expected to be between $0.71 and $2.52 per million gallons of water served. The average cost in 18 cities was $1.23 per million gallons. In cities with more than 800,000 people, the annual costs may be between $0.71 and $1.85 per million gallons. The average cost for 8 such cities was $1.22 per million gallons. The use of hydrofluosilicic acid in 4 cities with more than 800,000 people seemed to be most economical, the average annual cost being $1.10 per million gallons, compared with $1.22 per million gallons in 4 cities using sodium silicofluoride. In 18 cities, the average annual cost per capita for fluoridated water at optimal dosages established by the health authorities was 7.9 cents per capita. The average annual cost per capita in 8 cities with more than 800,000 people was 8.4 cents per capita.

7. There is no evidence that the handling of fluoride-bearing chemicals presents an employee health hazard that cannot be controlled. The normal measures dictated by accepted industrial hygiene practices are adequate to keep fluorides at safe levels in workroom air.

8. There is no evidence to indicate that any of the employees handling fluoride-bearing chemicals have been affected physiologically by their assignment.

9. There is evidence to indicate a loss of fluoride from filtration. Both naturally present and artificially added fluorides appear to be reduced in minor amounts. Two cities offer evidence of a reduction amounting to approximately 0.3 ppm in water passing through slow sand filters. The loss through rapid sand filters appears to be on the order of 0.2 ppm. There is no indication that fluoride accumulated on filter sands reenters the system.

Acknowledgment

The New York University research staff is indebted to all of those who have contributed information and otherwise assisted in the development

of data. The willing cooperation and interest of everyone concerned with this study are gratefully acknowledged.

References

1. AWWA Standard for Sodium Silicofluoride—AWWA B702-55. Am. Wtr. Wks. Assn., New York (1955).
2. AWWA Standard for Fluosilicic Acid—AWWA B703-55. Am. Wtr. Wks. Assn., New York (1955).
3. AWWA Standard for Sodium Fluoride—AWWA B701-54. Am. Wtr. Wks. Assn., New York (1954).

Effect of Fluoride on Corrosion of Iron, Copper, and Lead

In the June 1959 issue of *Sanitalk*, a publication of the Massachusetts Department of Public Health, an article by Joseph A. McCarthy reports the results of an investigation of the effects of fluoride on the corrosivity of North Andover, Mass., water. The water is a soft surface water, known to be corrosive. For several years before fluoride was applied, alkaline treatment had been used at the pumping station. The pH of water leaving the station has averaged 8.4 during the past 2 years.

By the time the water reaches the point of collection, approximately 5 mi from the pumping station, the pH changes considerably; it was 6.7 on the days of collection of the water used in the experiments. Equal portions of this water were drawn from a tap and placed in six 1-gal containers. To three of the containers was added enough fluoride to give a fluorine concentration of 1 ppm. Identical coupons of iron were suspended in a pair of containers with and without fluoride. The same was done for copper and lead. No attempt was made to produce flowing conditions, although each container was thoroughly agitated at least once a day.

The results of the analyses, shown in the table below, definitely indicate that the rates of solution of all three metals were nearly identical in water with and without fluoride and that the added fluoride had no effect on the corrosion of the metals.

*Solution of Iron, Copper, and Lead in Water With and Without Fluoride**

Contact Time *days*	Metal Concentration—*ppm*					
	Iron		Copper		Lead	
	Without Fluoride	With Fluoride	Without Fluoride	With Fluoride	Without Fluoride	With Fluoride
1	1.8	1.8	0.30	0.30	0.40	0.40
5	4.0	4.7	0.55	0.55	6.0	6.2
12	12	11	0.80	0.80	7.3	7.0
30	83	80	1.1	1.2	8.4	8.8
46	110	105	1.6	1.5	9.4	9.0

* Fluoride added equivalent to 1 ppm fluorine; analysis of water before addition of coupons was: iron, 0.28 ppm; copper, 0.10 ppm; lead, 0.00 ppm; pH, 6.7.

Legal Aspects of Utility Development and Operation

Edward F. Taylor

A contribution to the Journal by Edward F. Taylor, City Attorney, Redlands, Calif. This paper originated as part of a report presented to the convention of the National Institute of Municipal Law Officers, Chattanooga, Tenn., by the author, as chairman of the Committee on Municipal Water Problems, and published in the 1959 NIMLO Municipal Law Review. Other portions of the report were published in the July and August issues of the Journal.

COURTS and legislatures are constantly reshaping the principles governing water utility operation. When they take action, water utility policies should be reexamined. For instance, although there was not an unusual number of suits charging negligence from water operations during 1958, two cases from Missouri and another from Washington apply a rule that make it harder for a utility to defend against tort actions.

Liability Cases

One of Kansas City's mains cracked open, releasing water which damaged goods in the basement of a hat store. The jury's verdict (*1*) in favor of the city was reversed. The court granted a new trial and held that city liability for negligence could be based on *res ipsa loquitur*. Affirming the granting of a new trial, the Court of Appeals said:

> We agree that under the rule . . . the plaintiff's proof that its property was damaged by a break in a water main constructed and controlled by the city was sufficient to establish *prima facie* that the injury was due to negligence of the city.

Motion for new trial was granted in *Koch Brothers* v. *Kansas City* (*2*) after the jury found the city not liable for leakage of water from a city hydrant which damaged goods in a store basement. Affirming the order of a new trial, the appeal court held the city operated its water system in a proprietary as well as a governmental capacity. "This is a *res ipsa loquitur* case, and the plaintiff made a *prima facie* case of general negligence," the court said. It was shown that an employee failed to close a hydrant completely.

In *Kind et al.* v. *Seattle* (*3*), judgment was entered in favor of the plaintiffs for damage to their property resulting from flooding after a city water main burst. No negligence or fault on the part of the city was proved. The State Supreme Court of Washington observed:

> The city . . . has shown it was free of negligence in the operations examined, but it had not yet discovered the cause of the break, nor had it shown that it was free of negligence in regard to that cause . . . there is an inference, permissible from the occurrence itself, that it was caused by the defendant's want of care.

. . . Legal control or responsibility for the proper and efficient functioning of the instrumentality which caused the injury and a superior, if not exclusive, position for knowing or obtaining knowledge of the facts which caused the injury provide a sufficient basis for application of the doctrine [*res ipsa loquitur*].

In *Dougherty* v. *Sioux City,* the owner of a building damaged by leakage from a defective joint in one of Sioux City's water mains, obtained a judgment based on the negligence of city employees. It was affirmed by the Iowa Supreme Court, with four justices dissenting. The court held that a municipality operating its water system in a proprietary capacity is liable for injury caused to the property of a plaintiff by the negligence of municipal employees, under the doctrine of *respondeat superior.*

Although the evidence showed that the joint was defectively made, it appeared that the city's employees had observed water leaking through the pavement for several months and had been informed of seepage into the basement of the building. The trial court found the duration of the leak was such that the defendant was negligent in failing to eliminate it.

When the City of McAlester built a high, 1-mil gal water tower, the owners of an adjacent lot sued for damages (*4*). They alleged a constant threat of danger from collapse of the water tower, and that it was unsightly and destroyed the sales value of their home.

The Supreme Court struck down the complaint. Damages may not be recovered for wind whistling through the tower, cracks in the ground, rain deflected from the tower into their yard, mud, and prospects of damage from lightning, the court held. Mere incidental inconveniences of an unsightly structure not erected out of spite is not compensable, even though it may depreciate property values.

A farmer sued the Texas cities of Mission, McAllen, and Edinburg after heavy rains had flooded his crops (*5*). The court held he failed to make out a *prima facie* case against the cities. They had leased large acreage to the United States for a military base. The water reached the farm lands through a drainage canal built by the federal government across the cities' property. The court, however, found that the alleged nuisance was created by the United States, not the cities.

The action failed to prove the proper measure of damages and was barred by the 2-year statute of limitations.

In *Sargent* v. *Town of Alton* (*6*) a cottage owner sued for damage allegedly caused when an employee of the town opened a shutoff valve and allowed water to run through the line into the cottage. The faucet in the cottage had been left open for the winter because the pipe was located above the frost line. On appeal from the granting of the city's motion for nonsuit, the Supreme Court ordered a new trial, because the trial court erred in excluding the water commissioner's admission that the employee must have turned the valve on instead of off.

In *Lower Nueces River Water Supply District* v. *Live Oak County* (*7*), the appeal court dissolved a temporary injunction to restrain the water district from closing openings on a dam and inundating a county road and bridge over which the district was establishing its reservoir.

The county lost on theory of a duty on the district to quit work or build a high level causeway costing $750,000. Texas law gives the district authority to construct the dam and reservoir and

the county knew for more than 2 years its road and bridge would have to be changed to avoid inundating them, the court held.

When a homeowner sued for damages of a fire allegedly caused by a welding machine used to thaw frozen pipes, the town was held not liable for negligence (*8*). Affirming the trial court's directed verdict for the municipality, the Supreme Judicial Court found that the operator of the thawing device was an independent contractor. There was no evidence that any of the city employees did any work negligently or that the work was so ultrahazardous as to imply municipal responsibility for the independent contractor's work.

An irrigation district is a governmental agency in California and may not be sued in the absence of specific legislative authorization. On this principle, the San Joaquin County Superior Court sustained a demurrer filed by the Westside Irrigation District in a case involving damage claims and punitive damages by former employees (*9*). The court also held that the state's labor code does not apply to government agencies.

The complaint alleged that the men were wrongfully dismissed from their jobs after joining the union and that the district refused to rehire them unless they quit it. They claimed lost wages and punitive damages.

The district denied that union membership had been the cause of dismissal, but claimed that it had the authority to dismiss employees for such a reason. Judge Homer B. Quinn agreed, saying:

> It should be observed that the legislature has not delineated any areas of public employment to which the Labor Code sections should apply . . . it would not appear appropriate for a trial court to attempt to carve out any such areas. This would appear to be a legislative matter.

Land Acquisition Cases

One of the major roles of a municipal lawyer is to advise proper legal and business practices in land acquisitions for water supply. He may assist officials in avoiding future complications and expense by evaluating the types of land available, by establishing a reasonable land acquisition policy, and handling proceedings in eminent domain.

Of unprecedented importance today is the acquisition of property for impounding reservoirs. An example of the magnitude that the clearing of a reservoir site can assume, the Quabbin Reservoir of Boston's water supply affected fourteen towns, and four ceased to exist as political subdivisions. There were also 34 cemeteries located within the watershed. All bodies were removed to other cemeteries located beyond the watershed. It is particularly difficult to acquire land occupied by a cemetery because of the land ownership problem (*10*).

Although land is usually purchased by negotiation with the landowner, it may be necessary to condemn the land required if the asking price is too high, or when the owners refuse to sell. A city may offer some very good bargaining power if a farmer, balking at selling some of his bottom land, could be offered the opportunity to use it as grazing land for the majority of the time under a flowage easement. Naturally, each piece of land would require separate consideration, and the cost would depend on the quality of the appraisal and land acquisition staff involved in a project. It has been found to be most desirable to leave land ac-

quisition policies as flexible as possible, because Texas laws require that condemnation proceedings for property be tried in a local court. The land acquisition which cannot be settled amicably will be both time consuming and expensive (*11*).

It may be advisable to acquire one or all of the following three kinds of property:

1. The reservoir, or flooded area, including the necessary lands to construct the dam and other appurtenances
2. The marginal strip immediately around the periphery of the maximum flooded area at normal and maximum high water level
3. The drainage area, or watershed, either wholly or in part about the reservoir.

In preparing the reservoir area, it is sometimes necessary to provide for the relocation of bridges, highways, railroads, pipelines, and other facilities. For the Green Lane Reservoir on the Perkiomen Creek, just completed by the Philadelphia Suburban Water Company, it was necessary to relocate and raise a county highway. The cost of approximately $500,000 included construction of a new reinforced-concrete bridge to replace the last remaining covered bridge in Montgomery County, Pa.

The factors that affect the acquisition of these marginal strips differ from reservoir to reservoir. For some reservoirs, the preservation of the quality of the supply is the governing factor; in others, it is the control of silting from adjacent property; whereas in others it may be access to the reservoir.

To avoid liability for property damage, the water utility should own all property that might be inundated by high water, and should take into account all major recorded floods as well as all property that might be damaged or eroded by wave action. Flood rights should be acquired when feasible.

As a rule of thumb, as much marginal land as possible should be owned or controlled by the water utility, extending to an entire watershed area if possible.

This is the policy of many Pennsylvania communities. The borough of Sellersville owns 7 sq mi, the Hanover Municipal Water Works, 5.7 sq mi, and the Altoona City Authority, 4.4 sq mi.

The Metropolitan District Water Supply Commission of Boston acquired 126 sq mi surrounding Quabbin Reservoir.

The Miami Conservancy District of Dayton, Ohio, for flood control reservoirs, purchases the entire area where affected when the reservoirs are filled.

Pollution caused by increased use of watersheds for commercial, industrial, and agricultural purposes may make necessary the purchase of entire drainage areas to protect the water supply. The Municipal Authority of the Borough of Minersville, Pa., floated a special bond issue to purchase an entire watershed for protection from coal mining operations (*10*).

Seattle has obtained much of the Cedar River watershed to protect its Tolt water source (*12*). Some states regard the marginal strip of such importance that the legislature has entered the picture. Definite laws cover the subject in Arkansas and Missouri. But the municipal lawyer will advise compliance with practices strongly recommended in states without definite laws, such as Alabama, Connecticut, Iowa, Indiana, Kentucky, Massachusetts, Montana, New York, North Carolina, Texas, and Washington.

In general, municipal clients should be advised to acquire enough land for the reservoir water area, dam, and

other appurtenant structures, for control of access to safeguard water quality and permit operation and maintenance by utility employees, and to protect the utility from legal liability for property damage resulting from major floods or wave action that might inundate or erode adjacent property (*10*).

Eminent-Domain Actions

The federal government's first suit condemning farmland for the Putah South Canal in California resulted in a $55,750 award to the landowner. Added to $14,600 for 9.52 acres was a substantial severance damage of $41,150. The federal government's Putah South Canal, which will deliver water from Monticello Dam to farmlands in the Solano Irrigation District, would literally cut the owner's ranch in half (*13*).

Officials of the Santa Clara Valley Water Conservation District are appealing the court award of $8,755 in damages as a result of high water (*14*). The damaged building was located about 1 mi below the district's Almaden Reservoir. The district contended that it is not legally responsible once its reservoirs are full. The jury found the district should have maintained a lower water level. If upheld, the decision could mean that all water conservation reservoirs in the state must be used for flood control purposes.

An irrigation district widened one of its canals 20–30 ft to furnish water to additional land within its boundaries. As a result, it took nearly 2 acres more of land. The owner sued, despite a provision in his deed from the district allowing it to repair and replace the canal. The court held that the deed reservation did not give the district the right to take part of the owner's land many years later without compensation, and awarded $1,140 in damages. The court indicated that the deed allowed the district to construct other canals but not to widen an existing one (*15*).

The Greenwich (Conn.) Water Co. took certain riparian rights to fulfill its franchise to furnish water to towns both in Connecticut and New York. Connecticut property owners challenged the company's charter power to condemn for this purpose. Because the riparian owners failed to bear the burden of proving bad faith and because the trial judge found that the taking served a public use, the Supreme Court held it to be a proper exercise of eminent domain (*16*).

In Ohio, the water company supplying Marion dropped plans to dam the Little Scioto River and store water for the city's domestic needs. The County Board of Commissioners has no authority to authorize the dam and bind all the riparian owners in the Attorney General's opinion. Without express statutory power, the company "is a public utility and must acquire private property needed by it for its service to the public, including rights of riparian owners, in the manner provided by law."

Trends in Financing

Huge capital outlays will be needed for water systems in the years immediately ahead. Expansion is inevitable as the result of increasing population and the growing per capita use of water in the United States. The water industry must make itself as attractive as possible to both institutional and individual investors and be prepared to offer yields and protective provisions that will be competitive with those offered by alternative investments. Other issuers of securities will

be bidding just as strongly for capital funds. The sale of securities to institutional investors requires title searches and legal advice at every stage.

The water industry is in a favorable position for investment. It is the largest transportation industry in the country; it supplies a product which is indispensable; competition is virtually nonexistent; it influences the location of factories, businesses, and homes; most of its assets have a very long service life with obsolescence playing a very minor role; and its earnings are relatively stable.

The principal problems confronting policy makers and their legal counsel are how to provide for future expanding water needs, earn a fair rate of return, adapt financing plans to the radically changed state of the capital market, and sell the water industry's program to the public (*17*).

State Progress

An amendment to the Louisiana constitution will enable the state to pay for much-needed irrigation works. Prior to the amendment, there was no market for bonds because the owner of land within the district could not be taxed unless he actually used water. This undesirable feature was eliminated by extending the taxes levied by irrigation districts to all lands within the district whether or not any of the available water was used on the land. As a result, the legislature's authority to police juries throughout the state to create irrigation districts now means something. The district may not include incorporated towns and cities. All land that is incapable of receiving any benefit from the operation of the proposed district must be excluded from the district at the time it is created. All land included in the district is subject to taxation (*18*).

For financing the development of water supplies by long-range plans, carried out in stages, New Jersey authorized bonds in the aggregate principal amount of $45,850,000.

Water project construction requires large amounts of capital. For this reason, it is frequently beyond the financial capacity of local interests to develop new water supplies. The cost of facilities to transport water over long distances to the heavily developed agricultural and urban areas is prohibitive. Relatively undeveloped areas lack the assessed valuation or other tax resources to obtain the water essential to their growth.

They must look to major units of government, principally several large states and the federal government. These public agencies are capable of constructing the large, expensive water projects of the type needed in many instances to meet growing water requirements. Even when state construction is not desired, state financial assistance to local projects is sought. Solving all the legal, engineering, and other aspects of water problems is only half the job. No program can be accomplished without a sure means of raising the large amount of capital required for construction projects. Thus, the financial condition of the state becomes one of paramount importance in the policies for a state water resources development program.

California, with its vast expanse of semiarid lands that will one day bloom when water arrives, is evaluating its ability to finance the great projects ahead. The state's revenues are far from adequate to finance the present programs of the state, not to mention further requirements for water project construction.

Spurred into action by Governor Edmund G. Brown, the California leg-

islature has submitted a $1.75 billion bond issue for a vote of the people in the 1960 general election. These funds will launch a water resources development program unprecedented in world history.

The approximately $140,000,000 presently in the investment fund will be sufficient to finance the state's water project construction program for the first 2 years. But an average of $120,000,000 per year is required to finance the state's presently authorized construction program for the next 10 years. An additional $350,000,000 is needed by 1959–60 to finance the state's expenditure program, including water projects, if no new programs are added.

According to a California legislative subcommittee: [1] New taxes in addition to those required to meet existing general fund requirements and the sale of general-obligation bonds in excess of the present schedule are the only significant sources of construction funds; [2] great care in the authorization and timing of bond issues for water resource development, or for other purposes, will be required to preserve the state's credit position and avoid excessive interest costs; and [3] the state cannot continue, over an extended period of time, to issue bonds at the present rate of $310,000,000 per year without running into difficulties.

"The voters of the state and the legislature may have to decide between general obligation bond issues for water projects, veterans' loans, school aid, state building program, and other purposes," Assemblyman Jack A. Beaver of Redlands declared.

"Use of tidelands oil revenues as available, General Fund money as available, the balance in the Investment Fund, and general obligation bonds in predetermined proportions, now appear to be the only feasible method of financing the state's water development program."

Fire Protection

Inadequacies in municipal water supply affect every citizen's pocketbook as well as his security against fire. Without water to fight fires, fire insurance rates may be trebled. A spot check of one large city indicated the combined insurance bill of its inhabitants would rise $432,000 if the hydrants were removed (*19*).

In planning to meet future water needs, fire protection may be as important as surveys of water demands for residential and industrial growth. For instance, in residential sections, a fire flow of 500 gpm is a more important factor than several residential customers' simultaneous demands for domestic use. Consequently, fire flow is used as a basis for sizing lines.

Increased fire insurance rates are a strong argument against haphazard annexations of suburban areas. The annexed areas must have adequate distribution of hydrants, valves, and properly sized mains. If the area is to be fully protected, deferred fire insurance classifications to the newly annexed area will increase the deficiency against the city's total rating.

Fluoridation

All was quiet on the fluoridation front until the courtroom doors swung open for two major midwestern cities. Questions were raised as to the power of Chicago and Omaha to order fluoridation of their public water supplies.

There is now pending, in the Superior Court of Cook County, a "Complaint for Injunction and Other Relief," in which five plaintiffs are asking the court to issue a writ of injunction permanently enjoining the mayor of

Chicago, the comptroller, the commissioner of water and sewers, and the deputy commissioner for water from further applying fluoride to the water supply. Fluoridation had been authorized by city council order and has been applied to Chicago water since 1956.

An action for declaratory judgment by the city-county health authority in Omaha asks the courts to authorize the Omaha Metropolitan Utilities District to fluoridate the public water supply. The district's general counsel advised that it has no such police power as a proprietary municipal corporation.

A line of decisions in seven states accepts fluoridation as a reasonable measure to prevent tooth decay and places the practice within the police power of both general-law and charter cities. Although the legality of fluoridation is settled, it will probably linger as a policy matter to plague legislative bodies for years to come.

Ordinances intended to promote public health by providing for fluoridation have been upheld, despite contentions that they infringe upon individual liberty and religious freedom, subject people to compulsory medication, and take away parents' control over their children's health, and that dental care is a private health problem, not a proper object of government concern. The courts also reject arguments that flouridation is discriminatory or constitutes the illegal practice of medicine.

Service Outside City

The urgent call of the suburb for municipal water service has been answered differently from state to state. With no uniform system of laws or consistent approach by the courts, municipal counsel may advise local legislators to handle extensions of water service on a master-plan basis, as part of the city's annexation program. Any city granting outside service on any other basis surrenders its bargaining position. When it does so, it often finds the suburban area, although economically dependent upon the central city, fighting against annexation, while it continues to use the services provided by the city.

There is a way, however, by which the city may protect itself in this situation with reference to water service. This is to include in all water line extension contracts and all water service contracts a provision under which, as part of the consideration for the service, the property owner or developer waives his right to oppose subsequent annexation by the owning city. This exact policy is contained in a 1955 Indiana statute pertaining to the extension of sewers in suburban areas, and there is no reason why the governing board of a water utility, under its rule-making power, cannot invoke the same condition for water extensions.

Two attorney general's opinions, one from Ohio and the other from Missouri, raise interesting questions concerning outside water connections. The attorney general of Ohio was asked whether the constitution forbade a city to sell and deliver water to an industrial firm straddling the city limits. The industry used the water on its property both inside and outside the city. The attorney general found that the firm was an inhabitant of the city, and, as the water was taken by an inhabitant at a point inside the city, there was no violation of the constitution. The constitution imposes a limitation

on water service only to noninhabitants outside municipal limits.

An aggrieved property owner's demand that the Missouri Public Service Commission compel a county water supply district to extend service to his property was rejected by an attorney general's opinion. As a nonprofit government subdivision, the district is not a utility subject to the commission's jurisdiction, the opinion held.

Municipal Obligation

Five appellate decisions on the subject indicate no duty on the part of the municipality to grant a connection outside its corporate limits. Once it has granted water service, however, a municipal government may find it is legally barred from charging the nonresident at higher rates designed to make him pay his fair share. The lack of uniform laws makes it impossible to establish a general rule from the cases.

In *State* v. *City of Defiance* (*20*), an Ohio statute directing municipal corporations to furnish water to noninhabitants, against the city's will, and limiting the price charged, was held unconstitutional. The act was contrary to the Ohio Constitution, which, according to the court, empowers a municipality to sell and deliver a substantial portion of its surplus product to others than its inhabitants. An applicant for service had instituted a mandamus action to compel Defiance to issue a permit to tap into a water line.

A developer planned a shopping center of 26 stores, nine to be within the Lorain, Ohio, city limits and seventeen outside. Reversing the trial court's ruling requiring the service to occupants of the out-of-town stores, the appeal court said the constitution does not require the city to serve the interest of nontaxpaying noninhabitants (*21*).

In *City of Livingston* v. *Wilson* (*22*), the trial court ordered the Texas city to supply water to customers outside the city limits. Reversing this judgment, the Court of Civil Appeals said that the city was and is under no inherent duty to supply the water; state law confers the authority but imposes no duty, according to the opinion. It also found a monthly rate for nonresidents 50 cents higher per month than the rate for residents is not unjustly discriminatory.

Covington, Ky., brought action to set aside an order of the public service commission fixing rates for customers outside the corporate limits (*23*). The city's contention that a federal PWA grant of $178,099 for water utility construction was unlawfully excluded from the rate base was upheld. But the schedule of rates set by the commission was approved by the court. It rejected the city's contention that consumers outside the city must pay general obligation bonds of the city. It is entitled only to a fair return on its investment and "it is up to the people of the city, and not the consumers, to pay back the money," according to the court of appeals.

An action was filed to restrain the city of Asheville, N.C., from charging higher water rates for consumers living outside its boundaries. The court held (*24*) the ordinance invalid insofar as it established different rates for customers within water and sewer districts with systems maintained at their own expense. The court construed state legislation to mean the city cannot charge rates to water users

in those districts in excess of rates charged the residents of Asheville.

Pollution

Meeting municipal water needs requires more than finding a supplemental supply. It requires a positive program to make existing supplies usable, by curbing pollution.

When 3,000 communities annually dump 2,500,000 tons of raw sewage into the nation's streams, spoiling much-needed water resources and creating a health menace, it is hard to claim progress. Progress is, however, being made, in the sense that municipal government is holding its own after years of losing ground. Cost is no longer an excuse for spewing sewage downstream for the next fellow to handle as best he can; owing to the success of simple methods requiring little manpower, there was definite improvement in the nation's pollution habits in 1958.

When all else fails, strict enforcement is the key to the washing of polluted streams and many communities rallied to the support of antipollution measures. For instance, after the Connecticut Water Commission issued an order directing the City of Norwich immediately to abate pollution of the Yantic River, the people responded with a $1,600,000 bond issue for a new disposal plant (*25*). West Virginia's joint committee on government and finance and the commission on interstate cooperation have under consideration a bill which would prohibit the disposal of any kind of waste material in or within 100 yd of any river, creek, or stream or within 100 yards of the Yantic River (*18*).

In a novel approach to pollution control, the Virginia legislature provides a tax deduction for plants or equipment installed to prevent or reduce pollution, provided that the installation complies with the law (*18*). Georgia passed the Georgia Water Quality Control Act, which is a comprehensive pollution law. The board of health is authorized to require the use of reasonable methods which are scientifically and economically feasible to halt contamination of state waters. On the board is a representative of municipal government.

Although it has no general pollution law, Florida now requires a permit from the board of health to drill or use a well for the purpose of drainage of surface water or sewerage if the well is located within 5 mi of a city or town. Such wells already in use may be discontinued on board order. In this way, Florida is coping with past practice of drilling drainage wells into the porous limestone aquifers for the disposal of storm water, which resulted in serious pollution when urban centers and industries developed drainage wells (*18*).

The basic pollution law of Delaware is now supervised by the water pollution commission and administered by the State Board of Health. The law covers underground waters as well as surface waters. An unusual aspect of the Delaware law is its provision for arbitration. If a person prefers not to appeal to the courts, he may submit the matter to three reputable sanitary engineers, including one of his own choice, one appointed by the commission, and the third by the two engineers selected. The decision of the arbitrators is final (*18*). In Illinois, state regulation has forced many communities to take action to improve their waste disposal practices. More than 77.6 per cent of the population is

served by sewer systems, and 95 per cent of the municipal wastes reach treatment plants (*26*).

Trying for a water of better quality, South Dakota cities are moving realistically to obtain better treatment systems. Sioux Falls constructed a $1,100,000 plant for iron and manganese removal in 1955; Brookings recently let contracts totaling $174,400 for a similar facility; and Madison is voting on a bond issue of $395,000 for comparable treatment. Many of the smaller cities have pressure filter iron removal units. In the past 4 years, South Dakota has made the following improvements: seven new water supply systems; three new systems authorized or under construction; 66 new water supply sources in 52 communities; seventeen major remodeling projects; eight improved storage facilities; and four new fluoridation installations (*27*).

To assure high-quality water, the municipal authority of the borough of Minersville, located in the anthracite coal region of Pennsylvania, found it necessary to float a special bond issue to finance the purchase of its watershed in order to protect the supply against coal-mining operations (*28*).

An effective weapon against pollution of streams which cross state boundaries is control by interstate compacts. The compact entered into by Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia and West Virginia is designed to reduce contamination of the Ohio River. Since the creation of the compact, sewage treatment plants have been built to serve 75 per cent of the sewered population in the Ohio Valley. This involves 7,500,000 people and more than 800 communities (*18*).

Treatment works construction has accelerated to a new high with the introduction of the sewage lagoon. This device is essentially a shallow flat-bottomed pond. Sewage is introduced at the bottom near the center, and the growth of algae is the main purifying force. The oxygen released by the algae eliminates odor, and the pond itself has the appearance of a well maintained lake. Hundreds of lagoons are now in use throughout the Southwest and North Central states. Mississippi acted first in the Southeast with a lagoon in Prentiss, and, after that, Bay Springs, Houston, Wiggins, Raymond, and Brandon. These small towns set an example for larger sister communities, because the cost of lagoon construction is 30–60 per cent of that of a conventional sewage treatment plant. Low maintenance costs are another advantage.

Generally, estimates of pollution make little or no allowance for industrial wastes, although many cities have large amounts of industrial discharge entering their sewers. The list of towns and cities with new sewage treatment facilities, or in the process of constructing them, is growing. Federal grants amounting to 30 per cent of the cost, up to a maximum of $250,000, has spurred unprecedented anti-pollution activity.

Federal Intervention

In addition to giving assistance in making surveys and conducting research, the National Water Pollution Control Act authorizes the Surgeon General to take action when he finds that any pollution has become a public nuisance.

Louisiana was the first state to request intervention by the federal gov-

ernment concerning pollution of the Corney Creek drainage system. Testimony showed operators of oil well leases were discharging substantial quantities of acid salt brine, oil spillage, and other substances into the system. Fish, plant, and animal life were being destroyed. The waters were also unfit for watering stock, irrigation, municipal use, and most industrial uses. The board gave the offenders 90 days to start collecting the polluting substances and injecting them into underground formations (*18*).

Seaboard states are confronted with the special problem of salt water intrusion. On California's coastal plain, excessive draft has resulted in the intrusion of sea water into underground fresh-water deposits, thus impairing valuable sources of water supply. In many parts of the Central Valley, continuing ground water overdraft threatens the quality of freshwater deposits by upward movement of deep brines which were entrapped in underground basins in past geologic ages (*28*). The intrusion of salt water under the continental shelf toward Atlantic City, N.J., continues, and static water levels are now 61 ft below sea level. Excessive pumping adjacent to San Francisco Bay threatens to bring salt water into the aquifer (*29*).

Continual vigilance is necessary. Unless the high quality of the water is maintained, full satisfaction of the ultimate water requirements of municipalities will not be possible. There are still water utilities that are not properly protected to insure the safety of the water when exposed to a source of virulent infection. Recently, one district engineer found a city had interrupted its schedule of submitting bacteriological water samples. Further investigation showed the community's well had failed—a well drilled without the advice of a consultant and contrary to the recommendations of both the state geological and health agencies—and the community was pumping untreated lake water into the city distribution system (*27*).

Pollution has been recognized as a major threat to municipalities, industry, agriculture, and recreation only during the past 25 years. Its effect on the aesthetic beauty of every state is incalculable. Problems arise when the quantity of waste deposited is so great that the water cannot purify itself. Pollution to this extent adversely affects the people of the cities and towns located at or below the polluted waters, and nearby agricultural lands may be impaired and fish and other aquatic life and wild and domestic animals may suffer or be destroyed. A city's economy may be upset by the slightest change in water quality. Quality in large degree determines the extent to which water supplies can be put to beneficial use. Water of poor quality cannot be used for most purposes until it has been treated. But treatment, seldom practical for agricultural use, adds materially to the cost of water for municipal or industrial use.

The quality of water must be protected to the fullest practicable extent, to insure maximum opportunities for development and beneficial use. Pollution must be closely watched by state agencies, as well as by private parties, and any activity which causes substantial damage to riparian owners is likely to be condemned as unreasonable and hence actionable.

Inadequacy of Penal Statutes

Penal statutes do not insure satisfactory pollution control. When pollution comes from numerous sources,

it is difficult to fix criminal responsibility under the penal statutes. There is a vital need for prompt action when pollution approaches the danger point. Perhaps the most serious limitation inherent in any scheme of statutory control is its inability to cope with the variable nature of pollution. As has been observed, it cannot be determined whether the quality of water is objectionable without reference to the uses being made of that water. The necessary flexibility of control is possible only through administrative regulation.

There are encouraging signs of great progress. Badly polluted, once-dying rivers are being restored to new life. In Oregon the Willamette River is being cleaned up and there is hope the salmon may soon be running by the millions again. The grimy Ohio River, in the nation's heartland, is getting a head-to-toe scrubbing. Relieved of more than a 100 mgd of waste, New Jersey's Raritan River is running clean again for the first time in half a century.

Because water is industry's most used raw material, many firms have joined the fight. The chemical industry alone is spending $40,000,000 each year on the control of wastes from its manufacturing processes. Pulp and paper manufacturers have invested nearly $100,000,000 on treatment systems in the last decade; the pollution per ton of paper has already been cut to half of what it was 10 years ago.

The task of flushing the waterways is a gigantic one: The USPHS estimates that about 16,000 municipal and industrial treatment works, costing roughly $9 billion to construct, are still needed. But dollars invested in lessening pollution must inevitably bring tremendous benefits. "The damage done by pollution is costing industries and the American people at least $1 billion a year—maybe a couple of times more than that," says Gordon McCallum, chief of the Water Supply and Water Pollution Control Program of USPHS.

The new federal water pollution control act (Public Law 660) reaffirms the prime responsibility of the states in combating pollution, and strengthens state pollution control agencies through financial aid, research, and technical assistance. It gives USPHS enforcement powers to alleviate abuse of interstate streams. To assist communities in getting out of the pollution mess it offers as much as $50,000,000 a year for a minimum of 10 years. Of the 400 construction grants made to date, federal aid has paid an average of only 20 per cent of the cost. This relatively small involvement of federal money has stimulated tremendous spending by communities.

Spurred to action by the sight of once majestic rivers transformed into carriers of filth, municipal government has responded constructively to water supply needs. The dual challenge of assuring water quantity and water quality is being met vigorously and intelligently at last.

Resources Inventory

The major problem in municipal water rights law is the lack of basic meteorological, hydrological, and topographical data. Numerous agencies, both state and federal, within the limits of their budgets, develop and publish such data. In some instances, there may be an overabundance of data available, whereas in many others there is none at all. Unquestionably, a closer coordination of these activities will eliminate waste of time, effort, and money.

Accurate answers to water supply questions are sought by the water-resources-planner—whether an industry, city, or individual. Location engineers for large industry want dependable data on short notice, not vague statements about the availability, quality, and temperature of the underground water supply.

The phenomenal increase in the use of ground water for agricultural, industrial, and public use requires a continuing inventory of ground water resources in every region in the United States.

The USGS stands ready to cooperate in gathering and evaluating ground and surface water data. Many state agencies can also do the job, but a program to take stock of water conditions is needed to keep pace with demands for information.

A recently appointed Department of Agriculture committee has been charged with the responsibility of reporting on the need for an expanded research program on soil and water problems throughout the United States. Appointed at the request of the Senate Committee on Agricultural Appropriations, it will hold a series of public hearings to register the opinions of representatives from federal, state, and local action agencies concerned with soil and water resources (*30*).

In Mississippi, much information has been collected on ground water during the cooperative state-federal program. To find the facts on local supply, the city of Jackson is working with the Mississippi Board of Water Commissioners to evaluate the availability of ground water for industrial, municipal, and other uses within the area.

The University of California is establishing a new statewide water resources center for the purpose of providing a headquarters for its far-flung, advanced research activities. The center will serve as a clearing house for the information and technical data necessary to deal with the fast-growing state's water problems (*31*).

The 1958 New Jersey legislature directed the Department of Conservation and Economic Development to carry out a 10-year program of detailed geological and hydrological studies and ground water investigations to determine resources, quality, and supply potentials.

Texas' new water resources planning division is authorized to enter into contracts and agreements with muncipalities to carry out a joint program of topographic and geologic mapping of the watersheds and make studies of probable additional beneficial use (*18*).

Equally important are facilities to supply water during the most severe drought that can reasonably be expected. This requires the necessary reservoir volume and a large enough drainage area to fill it and maintain an adequate supply. Again, the need for more hydrologic data should be emphasized, particularly runoff data for small watersheds. Such data, if available, would lead to more concrete quantitative recommendations for future reservoirs (*32*).

Conclusion

In broad terms, the municipal water lawyer envisages his job as a twofold one. He must help protect existing water rights and urge policies and programs to develop additional water in the future for agricultural, industrial, municipal, and recreational purposes.

Unfortunately, many municipalities fail to adopt a sensible water policy until there is a scarcity. Shortages

occur from a lack of sufficient rainfall, from using up the available supply, or from polluting the available supply to such an extent that it cannot be used.

It is necessary to analyze the types of water laws and policies presently in use, find their defects and eliminate them. The purpose of a water policy is to regulate the appropriation, use, and disposition of water. This is necessary because water is seldom present in the proper amount and in the proper condition at the right place and at the right time.

Without an adequate water supply in the proper condition for use, our towns and cities, or any heavily populated area, cannot exist. Industry depends upon water for most of its manufacturing processes and as a means of inexpensive transportation. Agriculture is dependent upon an adequate water supply and has recently turned to irrigation in many areas. Water is also necessary for the fish and fur industries and for many types of recreation. In addition, watercourses furnish the means of disposing of most of the waste and sewage.

Many communities have been compelled by drought conditions to face their problems squarely. Some are still not officially concerned about the long-range crisis in water. Perhaps they are not aware of it.

The municipal attorney should urge local governments to evaluate their water supply needs and insist upon solutions before it is too late to avoid trouble.

Although droughts have focused attention on seasonal shortages and competition for supply, many suspect the fundamental problem lies deeper. The needs for water in all fields have expanded tremendously in recent years; and this expansion will continue. But the first inquiry is whether existing water law provides the maximum opportunity for beneficial development, use, and conservation of water resources and the full protection of private rights and the public interest.

References

1. *Adam Hat Stores, Inc.* v. *Kansas City* (Mo.) 307 SW 2d 36 (Oct. 1, 1957).
2. *Koch Brothers* v. *Kansas City* (Mo.) 315 SW 2d 743 (Jul. 14, 1948).
3. *Kind et al.* v. *Seattle* (Wash.) 50 Wash. (2d) 485, 312 P (2d) 811 (1957).
4. *City of McAlester* v. *King* (Okla.) 317 P 2d 265 (Oct. 29, 1957).
5. *Lance* v. *Tri-Cities* (Tex.) 308 SW 2d 546 (Nov. 27, 1957).
6. *Sargeant* v. *Town of Alton* (N.H.) 143 A 2d 411 (Jun. 20, 1958).
7. *Lower Nueces River Water Supply District* v. *Live Oak County* (Tex.) 312 SW 2d 696.
8. *Thurlow* v. *Provincetown* (Mass.) 149 NE 2d 901.
9. *Davis* v. *Westside Irrigation District* (Calif.) County of San Joaquin, Calif., Case No. 6635.
10. Friel, Francis S. Land Policy for Impounding Reservoirs. *Jour. AWWA*, **49**:1147 (Sep. 1957).
11. Graeser, Henry J. Reservoir Land Policy. *Jour. AWWA*, **49**:1159 (Sep. 1957).
12. Allen, E. Jerry. Seattle Watershed Access Policy. *Jour. AWWA*, **49**: 1170 (Sep. 1957).
13. *Western Water News*, **10**:4:2 (1958).
14. *Kambish* v. *Santa Clara Valley Water Conservation District* (Calif.) Santa Clara County Case No. 99298.
15. *Fisher* v. *Palo Verde Irrigation District* (Calif.) 320 P 2d 95 (Jan. 22, 1958).
16. *Greenwich Water Co.* v. *Adams* (Conn.) 144 A 2d 323.
17. Martell, Grant A. Factors in Evaluating Water Utility Securities. *Jour. AWWA*, **50**:215 (Feb. 1958).
18. Water Problems in the Southeastern States. Research Study No. 11 (Review of Research Study No. 5), Louisiana Legislative Council (Dec. 1957).
19. McKelvey, George I., Jr. Present Bond

Market Status. *Jour. AWWA,* **49**: 1107 (Sep. 1957).
20. *State* v. *City of Defiance* (Ohio) 148 NE 2d 221.
21. *VMJ Co.* v. *City of Lorain* (Ohio) 151 NE 2d 667.
22. *City of Livingston* v. *Wilson* (Tex.) 310 SW 2d 569.
23. *City of Covington* v. *Public Service Commission* (Ky.) 313 SW 2d 291.
24. *Candler* v. *City of Asheville* (N.C.) 101 SE 2d 470.
25. Case History of a Sewage Disposal Plant. *Public Management,* **40**:6:133 (Jun. 1958).
26. Illinois Water Supply—A Vital Necessity—A Growing Problem. Water Resources Committee, Illinois State Chamber of Commerce (1956). p. 21.
27. CARL, CHARLES E. Water Supply Developments in South Dakota. *Jour. AWWA,* **50**:211 (Feb. 1958).
28. Water Facts for Californians. Department of Water Resources (1958). p. 5.
29. BERRY, WILLIAM L. & HOWLETT, HERBERT A. Supplemental Water for the San Francisco Area. *Jour. AWWA,* **50**:679 (May 1958).
30. *Western Water News,* **10**:9:3 (Sep. 1958).
31. *Western Water News,* **9**:11:4 (Nov. 1957).
32. BAUMANN, E. ROBERT & CLEASBY, JOHN L. Effect of 1952-56 Drought on Iowa Impounded Water Supplies. *Jour. AWWA,* **50**:233 (Feb. 1958).

Revision of Soda Ash Standard (AWWA B201)

On Jan. 26, 1959, the AWWA Board of Directors approved the following revisions to AWWA B201–53—Standard for Soda Ash:

Section 10A—Density is changed to read:

> The apparent density of light soda ash shall range between 0.5 and 0.6 g/ml or between 31.21 and 37.45 lb/cu ft. (Dense granular soda ash has an apparent density between 0.94 and 1.05 g/ml.)

The title of Sec. 3C is changed to "Apparent Density," and this phrase is substituted for the words "specific gravity" in the equation in Sec. 3C.2. The following note is appended to this section:

> NOTE: Apparent density can also be determined by carefully filling (without packing) and weighing a box or measure with a value of exactly 1 cu ft. The weight of the filled measure, in pounds, minus the weight of the measure equals the apparent density of the material, in pounds per cubic foot.

The revised standard will be designated "AWWA B201–59."

Electronic Billing in St. Louis

Conway B. Briscoe

A contribution to the Journal by Conway B. Briscoe, Water Comr., St. Louis, Mo.

WITH electronic data processing, more water bills can be prepared in 1 hr than were formerly prepared in a full day, a speed of operation that will save St. Louis, Mo., more than $32,000 annually in water division clerical costs alone. As an offshoot of this streamlined bill processing, the city will save more than $14,000 a year as a result of reduced mailing costs. In addition to the increased speed and considerable cut in the costs of operation, the bills are more accurate and functional than ever before.

A total of 143,000 customers are billed twice annually. Of these, 16,000 are metered accounts. The remaining 127,000 are flat-rate users, grouped into six geographical districts and cycle billed to even out processing and mailing.

Fig. 1. Key-Punch Operation

Working from the meter readers' cards (left), the key-punch operator enters the current meter reading on the billing cards, which already carry the previous meter reading and other information.

Past Methods

In the past, metal address plates were used to prepare water bills. For flat-rate accounts, the billing information was all on the plates. For metered accounts, however, ledger cards, rate charts, and posting machines were needed. After the two-part paper bills were produced, two copies had to be stuffed into a window envelope, run through a postage machine, and mailed to the customer, who returned both copies to the collector with payment. The collector returned one receipted copy to the customer after payment; this copy was the permit required by law. With these methods, the output was limited to about 2,000 bills a day.

Present Methods

At present, the city's punched-card equipment * processes 20,000 flat-rate bills of an entire district in 2½ days. The punched-card electronic computer † calculates charges for the metered accounts in about one-eighth the time formerly required by a clerical staff. Although the new system has

* The machines mentioned in this article are products of Remington Rand, Division of Sperry Rand Corp., New York, N.Y.

† Univac, Model 120.

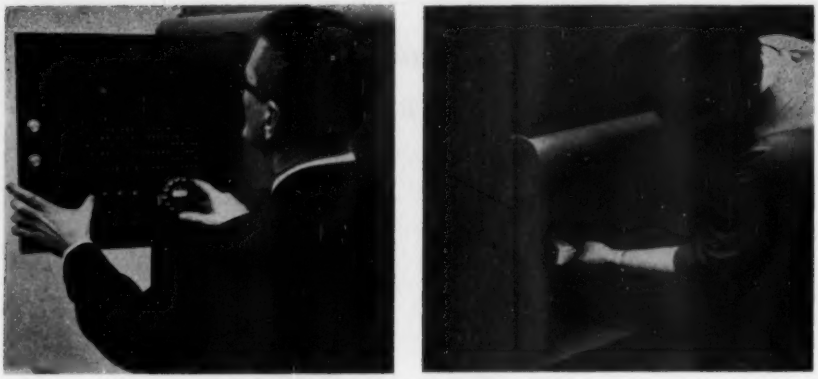

Fig. 2. Punched-Card Electronic Computer

A test is made of the billing program on the control panel of the computer (left). Billing cards are then fed into the machine for processing. In one pass, the computer determines the consumption; multiplies it by the rate to get the net amount; determines the tax; adds the two; verifies its figures; and punches the total. On the right, an operator removes the completed cards.

Fig. 3. Reproducer

This machine transfers the current meter reading to the previous-reading field of a new deck of cards, thus producing the billing cards for the next period.

been in operation for less than a year, it can safely be said that, at a bare minimum, the equivalent of the salaries of nine billing machine operators or similar personnel will be saved.

As part of this system revision, the ordinance requiring the mailing of water bill permits has been repealed. Bills are now prepared on thermoseal coated-paper stock,* processed to postcard size, and mailed for 3 cents—a saving of 5 cents per customer per semiannual billing at today's rates.

Metered-Account Billing

Metered accounts include all premises supplied by a unit larger than a single, ¾-in. corporation tap, as well as those accounts using water for commerce and manufacturing. To bill them, meter readers are supplied with punched cards that include the account

* Treated paper that can be sealed by heat.

number, address, and meter number. As the meter readers make their rounds, they post the current reading and the date on these cards. There is also a code column for recording such information as the location of leaks and inoperative meters.

These cards are given to the keypunch operators, who punch the information into the billing cards (Fig. 1). A billing card includes the account number, meter number, address, previous meter reading, and code for the type of rate—general or school, for example. The billing cards are then put through the electronic computer (Fig. 2), which subtracts the previous meter reading from the current meter reading and punches consumption in hundreds of cubic feet; multiplies the rate by consumption; calculates the tax (unless exempt); adds these; and punches the totals. It computes and verifies all this work in one pass of the cards.

Next, the billing cards are run through a reproducer (Fig. 3), with the amount, consumption, and previous-reading fields locked out. The current reading is transferred to the previous-reading field of a new deck of cards to get the billing cards for the next period.

Fig. 4. Collator

Address cards are merged with the completed billing cards.

Fig. 5. Tabulator

The combined deck is put through the tabulator to prepare the bills on thermoseal card stock.

The completed billing cards go through a tabulator, which produces an abstract of the meter bills. This serves as a permanent record for the collector's office, where "paid" will be stamped beside the bill when payment is received. Address cards are then merged with the billing cards on the collator (Fig. 4), and the combined deck is put through a tabulator (Fig. 5) to prepare the meter account bills on thermoseal paper stock.

These bills then go through a sealing machine (Fig. 6), which folds the paper stock double; seals the two thicknesses into one; prints a cycle number on each bill; counts the bills; and cuts them to the size of a postcard. The folded, sealed paper stock is then of sufficient stiffness to be acceptable to the post office for mailing.

Fig. 6. Sealing Machine

The thermoseal card stock enters at one end (left, in the photograph) and emerges folded, sealed, and cut to the size of, and made as stiff as, a postcard.

Next, the address and billing cards are separated, and the billing cards filed as an accounts receivable record. When the postcard bill is received by the customer, he tears off the stub and, in accordance with the instructions on it, mails the stub and payment to the collector's office.

Daily, the water department receives a list of paid water bills from the collector. The corresponding billing cards are taken out and, every week, processed through the tabulator to record the net amount, sales tax, and total. From this, the water department issues a credit memo to the collector for the amount of the sales tax. This amount is not on the stub he receives with the payment.

Flat-Rate Billing

Flat-rate billing is, of course, even simpler. Rates are based on factors such as frontage, number of rooms, and toilets, which do not change very often. These accounts are billed in advance on a deck of master cards, each of which includes the billing name, billing address, premises' address, account number, water service, net amount, sales tax, and gross amount. The 90-column capacity of a punched card makes it possible to get all this information on one card for each account.

To bill flat-rate users, the master deck is put through a reproducer to get a working deck complete with billing dates. This deck is tabulated twice, first to print the abstract, then to print the bills themselves on thermoseal stock, just as is done with the metered accounts.

Savings

The significant cut in clerical and mailing costs that has been realized

through use of this system, has not been offset by large outlays for equipment. The water division added only the sealing machines and two key punches to get the system in operation. The electronic computer and its associated equipment already were available, being used by the city for a variety of purposes.

Actually, costs are being cut and the efficiency of service increased just at a time when the city's financial problems make this particularly valuable. The use of punched cards for customer billing has been so successful that studies are being made of other ways in which this equipment can be used in the department.

Reprints Available

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Progress in the Construction of Chicago's Central District Filtration Plant

Fred G. Gordon and George S. Salter

A paper presented on Mar. 12, 1959, at the Illinois Section Meeting, Chicago, Ill., by Fred G. Gordon, Asst. Chief Engr., and George S. Salter, Chief Filtration Design Engr., Bureau of Eng., Dept. of Public Works, Chicago, Ill.

CONSTRUCTION of the Central District Filtration Plant is now far enough along that it is possible to illustrate some of the design features with photographs showing actual construction.

The plant is being built within a 61-acre cofferdam on Chicago's lake front north of Navy Pier. It will have a nominal capacity of 960 mgd based on a filter rating of 2 gpm/sq ft. The design, however, will permit operation at a filter rate of 3.5 gpm/sq ft, or the equivalent of a plant capacity of 1,680 mgd.

General Design

The plant is being designed by the Filtration Design Division of the Bureau of Engineering in the Department of Public Works, but the plans are prepared in consultation with the Department of Water and Sewers, which will operate the plant when it has been completed.

General descriptions of the proposed design have appeared from time to time in the technical press. These will be reviewed here only to the extent required to serve as a background for this discussion.

The general design is conventional, including low-lift pumps, mixing and settling basins, sand filters, clear wells, and a filtered-water reservoir. One intake will be provided by a water tunnel connection to the existing lake section of the tunnel from the Dever crib. The second intake will be from port gates at the front of the plant. Tunnel connections for filtered water are under construction between the plant site and the existing tunnel systems serving the pumping stations in the Central and North Districts. All tunnels are in rock.

The general dimensions and location of the plant were fixed by ordinance. The area is roughly rectangular with its length somewhat more than twice its width.

The desire to concentrate operating personnel and those facilities requiring the maximum attention within a minimum area near the center of the plant led to a design in which a central, north-and-south work strip is flanked on the east and west by groups of filters and settling basins. The filters are bisected by the long, east-and-west axis of the plant and the settling basins fill out the four corners of the plant rectangle. This arrangement permitted the location of the control room, the control laboratory, the chemical feeder rooms, the wash water tanks,

and the administrative offices near the plant's major axes. North of the facilities, in the central control area, are located the low-lift and wash water pump room, the power company's substation, the boiler room, shops, and store rooms. The south end of the central area includes chemical unloading facilities for railroad, truck, or barge; chemical storage areas; and, in the superstructure area, general offices, laboratories, and lecture rooms.

tire length of the south wall and portions of the north wall and a short section at the south end of the east wall. The cellular portion consists of a series of interlocking sheet piles with diaphragms. The cells are filled with crushed rock. This type of construction was used along the south wall in order to maintain as wide a slip as possible between the cofferdam and the north side of Navy Pier. The west side of the cofferdam and most of the

Fig. 1. Cofferdam Construction, 1955

Stone is being placed at the intersection of the north and west walls of the cofferdam.

Cofferdam

The first major contract in the project was for the construction of a cofferdam, which was required to make the site available for the filtration plant substructures and for three tunnel shafts.

Cellular and dyke construction were used for the cofferdam. A cellular cofferdam section was used for the entire length of the south wall and portions of the north wall and a short section at the south end of the east wall. The cellular portion consists of a series of interlocking sheet piles with diaphragms. The cells are filled with crushed rock. This type of construction was used along the south wall in order to maintain as wide a slip as possible between the cofferdam and the north side of Navy Pier. The west side of the cofferdam and most of the north and east sides of the cofferdam are a clay dike protected on the lake side by large limestone blocks (Fig. 1).

In order to provide a satisfactory foundation for the cofferdam, it was necessary to remove unstable material down to stiff clay (at an elevation of -25 ft). It was also necessary to remove a large amount of unstable silty sand over much of the area within

the cofferdam east of the north-and-south centerline. Equipment used for this purpose included dipper dredges and bottom dump scows. One of the dredges, "The Mogul" (Fig. 2), was said to be the largest on the Great Lakes.

Sand fill was used to replace the unstable excavated material and to bring the grade of the lake bottom up to an elevation of − 11 ft (the elevation of the underside of most of the major substructures). The final operation in the construction of the cofferdam was dewatering (Fig. 3). In order to maintain the stability of the cofferdam, the daily drawdown during dewatering was limited to 6 in.

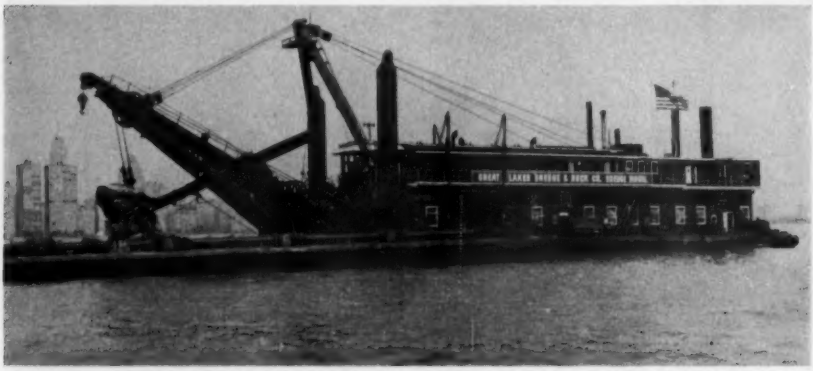


Fig. 2. 'The Mogul' Dredge Excavating for East Wall of Cofferdam, 1952

This dredge is said to be the largest on the Great Lakes.

Tunnels

An extensive subsurface exploratory program indicated that the elevation to rock at the site of the plant and along the line of tunnels connected to the existing tunnel systems of the North and Central Water Districts varied in depth from 60 ft to 135 ft below lake level. The exploratory program consisted of a series of borings over much of the area and a supersonic survey conducted as a joint project of the city and USGS. Use of the supersonic method was necessary because much of the tunnel work was to be done under the bed of Lake Michigan, which was otherwise inaccessible.

The dewatering of the cofferdam made that area available for the construction of shaft connections to the raw-water tunnel and the two filtered-water tunnels. The 20-ft raw-water tunnel will connect the low-lift pumping station intake basin with the present lake section of the Chicago Ave. tunnel. It will thus provide water from the Dever crib. The 16-ft filtered-water tunnels will connect the filtered-water reservoir with the tunnels presently supplying Central and North District pumping stations.

In addition to the three shafts just referred to, the tunnel contract included a shaft at Chicago Ave. and Lake Shore Drive, two shafts at Wilson Ave. and a work shaft just south of Belmont Harbor. The two shafts

at Wilson Ave. are part of a bypass between the tunnel from the filtration plant and a short tunnel that will connect with the lake section of the Wilson Ave. tunnel. There is a dry area in the channel that connects the two shafts.

The work shaft at Belmont Harbor was rectangular in section and some 226 ft deep. A dividing wall was constructed in this shaft, and provisions have been made for a connection with this shaft if and when a future tunnel is constructed along the line of Wellington Ave.

Equipment of the most modern type was installed in this shaft and for mining operations. An innovation of rock tunnel construction in the Chicago area was the use of a 14-in. hole in the center of the tunnel face which served as a breakout area during shooting (Fig. 4).

The combination of modern equipment and efficient operation was responsible for new records in the mining of rock tunnels in this area. The best progress for a heading in a single month was 1,733 ft.

Fig. 3. Cofferdam Dewatering Pumps, 1955

In order to maintain the stability of the cofferdam, drawdown of the water level was not allowed to exceed 6 in. per day.

A collapsible steel form was used in lining the tunnels. The sequence of operations was construction of the curbs, concreting of the arch section, and, finally, concreting of the invert. Ready-mixed concrete was used. The tunnels are now completed.

Reservoir

The reservoir is a reinforced-concrete structure 960 ft in length with

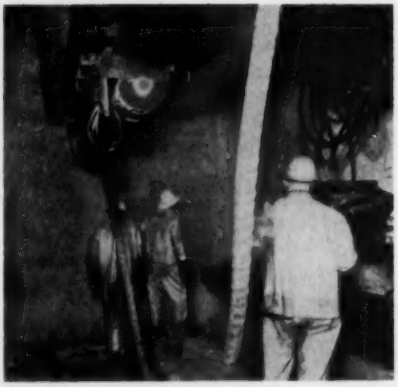


Fig. 4. Drilling in Tunnel Heading

The drill is shown boring a 14-in. relieving, or "burn" hole. This is the first time the method was used in the Chicago area for a rock tunnel.

an average width of 480 ft. It has a water depth of 20 ft and a capacity of 68 mil gal. Prior to its construction, a large number of test piles were driven and load tests were performed in accordance with the Chicago Building Code, in order to determine the proper length of the piles. Most of the piles were 45–47 ft long although some longer piles were required in a few areas.

The reservoir was designed with a monolithic, reinforced-concrete frame. Full account was taken of continuity conditions. No expansion joints were used in the structure, but more than the usual amount of horizontal-temperature steel was used in the walls. The west wall, being on a diagonal, has a total length in excess of 1,200 ft.

Another design feature is perhaps of more interest. A relatively short tunnel is required to connect the south half of the reservoir to the Central District tunnel system, whereas the tunnel connection from the north half of the reservoir to the North District tunnel system is nearly 5.3 mi long. It is desirable therefore to maintain a higher head in the longer tunnel than in the short tunnel if possible. This is accomplished by means of a series of openings in a wall that divides the reservoir into two unequal parts, control gates at the inlet and outlet of the reservoir, and suitable control of the flow of filtered water from the filters and their connecting conduits to the reservoir.

The tunnel that connects to the North District is served by the smaller section of the reservoir, whereas the tunnel connected to the Central District is served by the larger portion of the reservoir. Also, the 48 filters in the north half of the plant connect

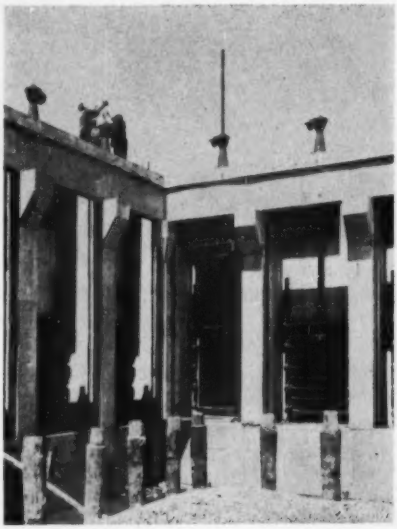


Fig. 5. Northwest Corner of Gatehouse

The gates permit individual or combined operation of the unequal sections of the reservoir.

directly to the north half of the reservoir, and the 48 filters in the south half of the plant connect directly to the south half of the reservoir. Inasmuch as water use in the North District is only slightly more than one half that of the Central District, and all filters will be operated at about the same rate, the excess filtered water going to the north half of the reservoir will flow through the series of openings in the dividing wall, and an essentially constant water elevation will be maintained in the north half of the reservoir. Any fluctuation in water levels will then take place in the portion of the reservoir serving the Central District, and a maximum hydraulic gradient will be maintained in the tunnel to the North District. The control works at the outlet shafts provide the necessary gates to permit the operation described above, or the reservoir may be operated as a single unit (Fig. 5). When required, one or both sections of the reservoir may be dewatered without interrupting flow to the two tunnels.

The construction of the reservoir was completed in 1957, and it is now being used for storage of equipment for the plant.

Filters

Operating experience at the South District Filtration Plant was used extensively in determining the size of the Central District Filtration Plant filter units. The South District filters each have a nominal capacity of 4 mgd. The wash water troughs span the width of the filter and connect to a side gullet into which connections are made for both the effluent and the influent. The filters are equipped with fixed surface wash. Preliminary studies on the Central District plant envisioned the use of filters of 8 mgd capacity, using the South District pattern but converting it into a double unit with a central gullet. This would have required 120 filters. The final plan is of essentially the same design, but the filter length has been increased to bring the nominal capacity of each filter unit to 10 mgd and reduce the number of filters to 96. One modification of the South District pattern was

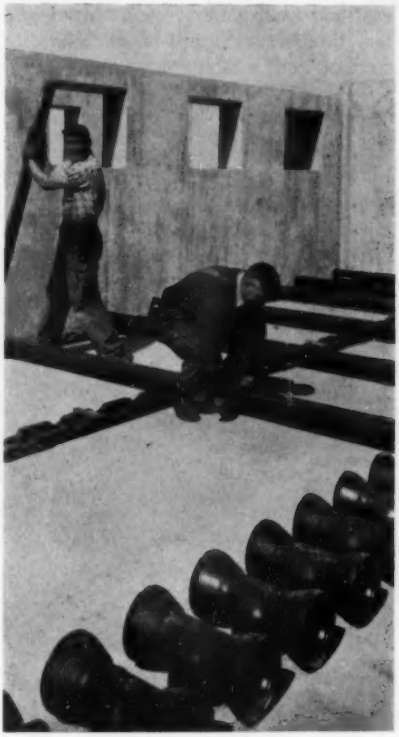


Fig. 6. Laying of Cast-Iron Laterals in Filter

The specifications for the cast-iron underdrain system permitted the use of slip-on joints.

to place the drain at the back of the filters, taking the wash water collector out of the filter gallery and providing a separate wash water collector between each group of six filters.

Filters are arranged with operating galleries at right angles to the main east-and-west gallery. Each filter gallery thus serves a unit of six filters for control and washing purposes.

The filter substructures include not only the 96 filter boxes but also eight clear wells and two filtered-water channels, which conduct the filtered water to the reservoir. The work on the filter substructures was almost complete by the end of 1958.

Filter Equipment

In the contract for furnishing and installing the underdrain system, wash water troughs, sand, and gravel, three alternative types of underdrains were specified. The low bid was on cast-iron laterals, and the contract was awarded to the low bidder. The underdrain system (Fig. 6) is therefore of the same type as that used at the South District Filtration Plant. The specifications permitted the use of the recently developed slip-on joint.

Settling Basins

The contract for the settling basins was awarded in July 1958 at the contract price of $14,730,374 and is the largest single contract yet awarded, not only for the Filtration Plant, but for any Chicago project. The contract covers the construction of sixteen settling basins, four to each quadrant. Each basin is of the double-deck type, in which the water flows first through a mixing channel and then along the length of the upper deck, returning to the lower section, from where it passes

Fig. 7. Settling Basins

The contract for these basins was the largest single contract ever awarded by Chicago.

into settled water collectors and thence to the filters (Fig. 7). Sediment removal equipment will be provided in the upper section only with provision for continuous sediment removal during the time the scrapers are in operation. The mixers in the mixing channels are similar to those used at the South District Filtration Plant, in that paddles are attached to horizontal shafts and the flow is parallel to the shafts.

Low-Lift Pumps

The selection of the low-lift pumps posed some interesting problems. These included pumpage rates varying from 400 to 1,700 mgd, a limitation by the power company on starting input to motors, varying heads on suction and discharge, and the need to conserve space.

The maximum size of the pumping units was limited by the largest motor which could be used—1,500 hp. In addition to the larger units, smaller units were selected to provide a smooth transition from minimum to maximum pumpage. It was, of course, desirable to limit the number of the smaller size units to the minimum that could produce, with various pump combinations, a capacity pattern with suitably uniform increments. Consideration of these factors led to the selection of six large units and two small units. The design capacity of each of the large units is 260 mgd, and that of the two small units is 170 mgd. With these sizes and proper pump selection, increases or decreases in pumping rates can be made in steps of approximately 85 mgd. With filter rates controlled by a fixed filtered-water reservoir level, variations in consumption and pumpage may be readily absorbed by varying the elevation in the settling basins and filters within a range of about 18 in.

Under the provisions of the contract the successful bidder was required to build models of each size of pump and test them for efficiency, capacity, reverse runway speed, and freedom from cavitation before proceeding with the construction of the prototypes. The model tests were met successfully, and the pumps are now being delivered to the plant.

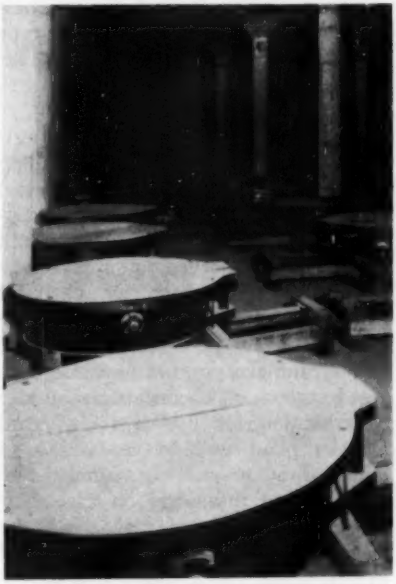


Fig. 8. Butterfly Valves in Storage

These 42-in. butterfly valves are being stored temporarily in the reservoir. A contract for 313 such valves was let in 1957.

Butterfly Valves

Butterfly valves will be used extensively in the plant. All filter valves and many valves on the backwash

and surface wash lines will be of the rubber-seated butterfly type. The decision to use valves of this type came only after long experimentation and considerable use at the South District Filtration Plant.

A contract for 313 of these valves was let during 1957, and a good portion of these valves has already been delivered. The contract for wash water piping will include approximately 240 valves of the same type (Fig. 8).

Chemicals

Chemicals will be received by railroad, truck or barge at the unloading area at the south end of the central strip. From there they will be transferred to storage tanks or bins and then moved as needed to supply tanks or bins located above the chemical feeder rooms near the center of the plant.

With the exception of lime and activated carbon, all chemicals now under consideration for use at the Central District plant will be received in a liquid form or will be immediately converted to that form on arrival at the plant. Activated carbon will be received in covered-hopper cars and will be made into a slurry in concrete tanks located below the track.

Track facilities for unloading chemicals include one receiving track for chlorine and two additional tracks for other chemicals. The three tracks are housed. The track for receiving chlorine shipments is adjacent to the evaporators, feeders, and chlorine storage area, all of which are isolated from the rest of the plant by partitions with provisions for adequate ventilation. The chlorine track is equipped with track scales. The track adjacent to the chlorine track will be used for receiving activated carbon and lime. The third track has unloading facilities for other chemicals. Tracks are paved and most of the chemicals to be received in the third track area will normally come by truck. In addition to the three receiving tracks there is a runaround track to facilitate handling of freight cars.

The use of chemicals in a liquid form has greatly simplified the storage and transportation problems. A notable example is the receipt of activated carbon in bulk, its conversion to a slurry, and its subsequent storage and application in that form. The possible variation in the use of activated carbon has been well illustrated by operating experiences at the South District Filtration Plant, where as little as 1,600 lb or as much as 80,000 lb has been fed per day. In general, storage facilities have been provided for 90 days' usage for the various chemicals.

Development of Filtration Plants for Small Communities

Joint Discussion

A joint discussion presented on Sep. 10, 1958, at the Michigan Section Meeting, Grand Rapids, Mich.

New Plant at Bridgman—*Theodore C. Williams*

A paper presented by Theodore C. Williams, Williams & Works, Grand Rapids, Mich.

BRIDGMAN, Mich., lies approximately 15 mi south of Benton Harbor–St. Joseph on the shore of Lake Michigan. The 1950 census showed a population of 977 and the estimated population in 1955 was 1,100.

The original water supply consisted of a series of 3- and 4-in. shallow tubular wells on the beach. Water was pumped by suction through a header with a horizontal centrifugal pump. At that particular section of the shore at Lake Michigan there is about 12 ft of sand on top of clay. The sand near the well point system is very fine, which makes a fine screen necessary on the wells. Because the wells were pumped by suction lift, the screens tended to encrust rapidly. As the lake level changed, the points had to be moved close to the water's edge—but not too close. In winter the ice on the lake stopped vertical percolation; the result was that more of the water came from the direction of the shore. The ground water from the land side has a much greater hardness and iron content. During times of storm the equipment was subject to damage by flotsam, and during the winter by ice. Always there was a danger of pollution because of the shallowness of the system.

Search for New Supply

The heavy maintenance cost and the unreliability of the system prompted city officials to consider other sources of supply, and in 1951 an engineering report was presented in which two courses of action were suggested: [1] construction of a lake intake and filter plant at an estimated cost of $400,000, or [2] exploration for ground water in areas inland from Lake Michigan. There was some evidence that a satisfactory ground water supply could be developed east of the city. Because of the lower potential cost of this plan, it was adopted. Test wells were drilled and pumping tests were run, but the best area that could be found would support only two wells with a combined capacity of less than 200 gpm—hardly enough to warrant a development. After the testing program another report was submitted in which an infiltration gallery along the lake shore was considered in place of the

existing well point system. The cost of the infiltration gallery was estimated at $95,000.

In 1953 the city acquired title to additional lake frontage, and in the spring of 1954 test wells were drilled along the frontage and in Lake Michigan. Tests indicated a coarser formation about 150 ft out in the lake, extending from the lake bottom to a depth of approximately 12 ft. Thus, the construction of a horizontal collector, additional storage, and distribution improvements were recommended at an estimated cost of $160,000. These recommendations were accepted by the city commission and steps were taken to implement them.

Area Authority

At about this same time, however, a long-time dream of a regional water authority that would serve the area from Bridgman to the Indiana line, 20 mi south of Bridgman, was resurrected by the Michigan Department of Health. The Bridgman project was suspended for several months pending a feasibility study of the proposed authority. This feasibility study was presented to the constituent municipalities in December 1955. The cost to Bridgman of obtaining water from such an authority exceeded, by an appreciable sum, the cost of providing its own production facilities. On the basis of the proposed authority financing, Bridgman would be responsible for a $700,000 share of the capital cost of the authority, as compared to an expenditure of $260,000 for its own project. The annual wholesale charge to support the authority would have been about $0.90 per 1,000 gal.

Decision to Proceed

At the time of the 1954 report, the Michigan Department of Health had some reservations as to the safety of this source, based on the shallowness of the aquifer available, and stated that, should the quality of the water produced be unsatisfactory for treatment by chlorination alone, the city would be expected to provide the necessary additional treatment. Discussion with the city officials then centered about:

1. The possibility of the water not requiring treatment other than chlorination
2. The additional cost of constructing a treatment plant later rather than as a part of the project
3. The adverse public reaction to a possible second project shortly after the first project was completed.

Deliberations culminated in the signing of an agreement for engineering services in July 1956 for the design of a collector intake, filtration plant, storage, and distribution improvements. A financial study and water rate analysis was prepared and new water rates were adopted and made effective in December 1956.

Educational efforts by the city officials, pointing out the need for the project and the costs involved, resulted in a 4:1 vote in favor of a $100,000 general-obligation issue in July 1956. A $210,000 revenue bond issue was set up to provide an average overcoverage of 1.6 with a minimum of 1.51. There were two reasons for this high coverage: [1] to make the revenue bonds more salable and [2] to permit use of surplus income for paying off the general-obligation bonds and make a general property tax unnecessary after the first 5 years, except as necessary to pay the fire protection charge of $100 per hydrant.

Construction Contract

Plans and specifications for the various sections of the project were com-

pleted and construction bids received on Apr. 10, 1957. The total of the low bids on the project was $276,255. Although the low bidder was not known to be experienced in this type of construction, the firm had been engaged in heavy construction for many years. The next lowest combination of bids brought the project total to $316,000—the difference being in the construction of the collector. Contracts were finally awarded to the low bidder, and on Jul. 30, 1957, the bonds were sold at 4½ per cent net effective interest on the general obligations and 5 per cent on the revenues. The construction contracts were formally signed and work started on the project. Everyone breathed a sigh of relief—at last Bridgman would have a dependable adequate water supply.

Construction Difficulties

On Nov. 20, 1957, the resident engineer met a Michigan Highway Department survey team working on the relocation of a highway and was informed that the new reservoir site, which was yet undeveloped, was within the right-of-way of the new highway.

The city had title to the site and could have gone ahead with the construction, but the highway department said that their new route was firm and that they would rather pay for relocating the tank now than pay for tearing it down and relocating it later. A study was made of the alternative sites for the reservoir outside the proposed right-of-way, together with the hydraulic and functional requirements of each site. It was determined that the least expensive solution was to move the reservoir to the treatment plant site, build it of reinforced concrete rather than steel as an addition to the clear well, install auxiliary power for high-lift pumping during power outages, and then construct a new 10-in. pipeline parallel to the existing 8-in. line from the treatment plant to the business district.

The additional cost of this change was to be borne by the highway department; in the long run, it would save the department an appreciable sum of money in not having to acquire and remove the tank from the site originally proposed. This plan was accepted in February 1958.

On Jan. 15, 1958, the contractor filed suit in a federal district court for a declaratory decree and asked for an additional payment of $15,000 in addition to the contract sum. The contractor contended that the city had knowingly defrauded him into signing the contracts and that the subsurface conditions were not those described at the time of bidding. The contract documents had, in fact, spelled out very clearly in three places that any information regarding subsurface conditions was intended to assist the contractor in preparing his bid and that the owner did not guarantee the accuracy of such information.

It should be mentioned here that the specifications for the collector were of the performance type and left many details of construction to the contractor's option. They provided that the collector yield 1,250 gpm during the month of August and that the water produced be substantially free of sand. The contractor, at the time he filed suit, had constructed the caisson and laterals and was starting to worry about meeting the performance tests. The case never came to court, as it was discovered that the contractor was not registered with the Michigan Corporation and Securities Commission and was, therefore, not entitled to do business in Michigan. The contracts were voidable. The city notified the

contractor to leave the job and that the work would be completed by others.

New Contract

On Apr. 28, 1958, a negotiated contract for completion of the project was signed with the contractor who had been second bidder for the original contract. The new contract included the changes brought about by relocation of the reservoir site.

The collector laterals have been developed to substantially sand-free conditions. When test-pumped at the maximum rate of the equipment available, they produced 1,600 gpm with a drawdown of only 2 ft out of an available 16 ft.

The new contractor has made excellent progress, and it is expected that the plant will be completed within a month or so.*

Joint Supply for Two Cities—*Clifford H. Spicer*

A paper presented by Clifford H. Spicer, Spicer Eng. & Assoc., Saginaw, Mich.

A rapid sand filtration plant has recently been placed in operation at the city of East Tawas, Mich., and supplies both East Tawas and Tawas City. The plant uses the solids-contact method of coagulation and sedimentation as well as rapid sand filtration. It has been suggested that some of the problems that arose in getting this project under contract and completed would be of interest to others who have similar projects.

East Tawas is a summer resort community located on the shore of Tawas Bay almost directly across Saginaw Bay from the tip of the thumb of Michigan. The city has a year-round population of 2,500. The influx of resort people during the summer months approximately equals the permanent population. A majority of the visitors stay in the state park on the shore of the bay adjacent to the water plant.

Tawas City is located on the shore of Tawas Bay just south of East Tawas. The two cities have a common boundary line and the proximity of the two cities has resulted in much rivalry and occasionally in controversy.

Supply Problems

For many years East Tawas has obtained its water supply from Tawas Bay through a 16-in. intake, which extends a distance of approximately 1,400 ft into the bay. The bay water has always been supplied to the people with no treatment other than chlorination.

The turbidity of the raw water varies from 2 to 40 or 50 ppm when there is a strong southwest wind. The average turbidity is about 5 ppm, and the total hardness varies from 95 to 100 ppm.

The water intake well, pumping station, and a 75,000-gal elevated tank are located on the shore of the bay at the foot of Newman St., which is the main street of East Tawas. For the past 15 years or more there has been a long municipal dock extending out

* [The plant has since been completed. It was placed into operation on Nov. 11, 1958, and was turned over to the city completed on Jan. 10, 1959. During the first 2 weeks the plant was operated manually because all of the control equipment components had not arrived, but since Dec. 1, 1958, the plant has operated continuously with no difficulties.—Ed.]

into the bay from the foot of Newman St. The dock provides anchoring berths for approximately 24 large pleasure yachts, some of which are used as summer homes. This condition and the fact that the beach adjacent to the water plant is used for bathing create a potential water pollution problem that has been recognized by the Michigan Department of Health for many years.

Engineering Study

In 1953 the author's firm was engaged to make a study of the water problem at East Tawas and submit a report. At approximately the same time the firm was employed by Tawas City to obtain a more adequate water supply from deep wells.

Well water in Tawas City is very hard and has a high chloride content. It was also becoming increasingly difficult to obtain well water in sufficient quantity to supply the needs of the city. The present estimated year-round population is 2,000, and the summer population is estimated to be 3,500.

As there is an unlimited supply of chemically good water in Tawas Bay, the logical and most economical solution of the water problem was to supply filtered and treated bay water to both cities through one filtration plant. This plan would reduce the overall first cost, reduce the operating cost, and result in an excellent supply of clear, soft water to both cities.

In the engineer's report submitted to the East Tawas Board of Public Works in September 1953, it was recommended that a filtration plant be built to serve both cities. Two plans were suggested whereby this could be accomplished. One plan proposed that East Tawas finance and build the filtration plant and sell water to Tawas City under a long-term contract at a rate acceptable to both cities.

The other plan proposed that a water authority be established by referendum and legislative action. The water authority would then finance and operate the filter plant supplying water to both cities.

East Tawas already had an intake and a pumping station which could be used with a filter plant, and, because of the apparent difficulty of obtaining a favorable vote to establish a water authority, it was recommended that the first plan be adopted. It was further recommended that a filter plant with a capacity of 1.75 mgd be built to serve both cities.

The maximum daily use in 1953 was 550,000 gpd in East Tawas and 180,000 gpd in Tawas City, or a total of 730,000 gpd. Consumption is high in East Tawas, probably because the supply is unmetered.

From September 1953 to June 1955 East Tawas took no action to start construction of the filtration plant. During this period, however, the Engineering Division of the Michigan Department of Health urged the city by letters and personal request to proceed with the water improvement project.

Failure of Cooperation

In June 1955 the East Tawas City Council authorized the engineering consultants to prepare construction plans for a filtration plant. Before construction could be started, however, it was necessary to know if Tawas City would purchase water from East Tawas. Unfortunately, at that time the location of a new consolidated high school became a very controversial issue. Each city wanted the school located within its boundaries. In the end, the new school was located out-

side both cities. Feelings became so bitter over the school issue that all hope that Tawas City would agree to purchase water from East Tawas was abandoned. A joint meeting of city councils confirmed the hopelessness of the venture. The capacity of the proposed East Tawas filtration plant was therefore reduced to 1.5 mgd, and in September 1956 a construction permit was issued by the Michigan Department of Health.

Bids were received on Oct. 22, 1956. The low bid of $269,105 was about 20 per cent higher than a preliminary estimate made 2 years previously. The contract was awarded contingent upon the sale of bonds. A financial consultant was employed to process a bond issue. At first it was the consensus of the city council that the bond issue would consist of both general-obligation and revenue bonds. Owing, in part, to the difficulty that had been met in getting support for the school issue, it was finally decided that the entire issue would be revenue bonds.

A 30-year revenue bond ordinance for $300,000 was adopted on Dec. 10, 1956 and published on Dec. 13. An application to the Municipal Finance Commission was filed later in December and was approved on Jan. 22, 1957. The bonds were sold on Feb. 13, 1957 at 4.21318 per cent interest, and the money was finally available on Apr. 1, 1957.

Cooperation at Last

Meanwhile, after having drilled a relatively unproductive test well, the Tawas City Water Board began to realize that an ample supply of filtered water from East Tawas would be very desirable. The East Tawas Water Board, during the process of establishing a source of revenue to retire the $300,000 bond issue, came to the realization that Tawas City would be a good customer.

At a joint meeting of the Tawas City Water Board and the East Tawas City Council on Nov. 19, 1956, it was recommended that a committee be appointed by the mayors of both cities, consisting of 4 men from each city, the two city attorneys and the consulting engineer, to draft a contract for the sale of water to Tawas City.

Both cities approved the recommendation and a committee was established. After two or three discussion meetings, a draft of the contract was prepared providing for the sale of water to Tawas City at $0.21 per 1,000 gal with a minimum charge to be based upon fixed costs and operating costs prorated according to population. Both city attorneys then went over the rough draft and added their ideas and legal phrasing. The two attorneys and the consulting engineer completed the final draft, which was approved by Tawas City on Apr. 30, 1957, and East Tawas on May 2, 1957. The contractor started work on the plant early in April 1957 and the plant went into operation in May 1958.

The water use on the maximum day prior to the installation of the East Tawas filter plant was 550,000 gal. During a period of extremely dry weather in the summer of 1958, water consumption increased to 700,000 gpd. The lack of customer meters accounts for the high consumption, and metering of all users is recommended in the near future.

Chapter 9—Maintenance and Repair of Positive-Displacement Meters

AWWA Meter Manual

A manual on water meter selection, installation, testing, and maintenance has been prepared by AWWA Committee 8610—Meters. This is the last of four installments (see June, p. 799; July, p. 913; August, p. 1022). The Manual will be issued as a separate volume (date and price to be announced).

THE maintenance and repair of positive-displacement meters,* particularly in the small plant, is discussed in this chapter. It should be mentioned at the outset that every new meter should be tested before being placed in service, so that a complete history is available when the meter is eventually brought in for inspection or repair.

Disc Meters With Two-Part Chambers

Cleaning

Every meter coming into the shop for repairs should be dismantled and all parts should be thoroughly cleaned, as shown in Fig. 9.1. If there is no time to clean a meter immediately, one end of the spud should be capped and water should be run into it under a faucet. When the meter is full of water, the top or open end of the other spud should be capped, and the meter should be allowed to stand in an inverted or upright position until it can be dismantled. This method keeps the deposits from the water soft and makes dismantling and cleaning easier.

A cast-lead block, approximately 1 ft square and 2 in. thick, is a very handly tool for the meter repairman. When disassembling a meter that has been in service for many years, it is sometimes difficult to remove the interior parts from the casing. In that event, the meter can be picked up, after the bottom has been removed and given a few sharp blows on the lead block to break the seal between the chamber and the casing. The block will take the impact and will not nick or damage the casing.

Numerous methods and chemicals are utilized for cleaning water meters. Hot alkaline solu ions are used to wash off oil and grease films, and cold acid solutions remove lime deposits, rust, and corrosion. Rubber in meters is not normally affected by either acid or alkaline solutions, but the temperature at which alkaline solutions are usually employed (approximately 160°F) would ruin hard-rubber parts. Regardless of which type of solution is used, meter parts should be rinsed in clean, cold water before reassembly to avoid corrosion from acids remaining in the crevices. Overdipping in strong acids should be avoided.

* Because designs of other types of meters vary widely, uniform procedures are impossible and, therefore, are not given in this manual. Information on maintenance and repair can usually be obtained from individual manufacturers.

Fig. 9.1. Dismantling and Cleaning of Meters in Shop

If not dismantled immediately upon arrival in the repair shop, meters should be sealed with water inside and stored in an inverted position. The water keeps any deposits inside the casing soft and easily removable.

Chamber and Disc

An inspection of the inner parts of the meter should start at the heart or motor, which is the chamber and disc (Fig. 9.2 and 9.3). First, the chamber should be inspected for pit holes. If the ball sockets of the chamber are very badly pitted, a new chamber is recommended. If the ball sockets are in good condition, even though the cone or surface of the chamber may be pitted, it may not be necessary to throw the chamber away. A little experience will soon enable the repairman to exercise proper judgment.

If the meter disc has a thrust roller, the slot should be checked for excessive wear and corrosion. If the chamber has a thrust roller insert (or bearing plate, as it is sometimes called) that, too, should be examined. If not, it is possible to send the chamber to the manufacturer to have it slotted for the thrust roller insert, if the rest of the chamber is in good condition and the wear of the slot is not more than $\frac{1}{16}$ in. An alternative method for reconditioning a chamber with a worn thrust roller slot is to use a slot channel insert and a special thrust roller. Should it be necessary to replace a partition plate, the clearance between the disc ball and the plate must not be too great, or it will permit water to pass from the inlet to the outlet of the chamber without registering on the meter. The partition plate must be tightly secured; a loose plate will rub on the disc ball, causing friction and meter failure.

Next, the disc should be checked with a straightedge to see if it has been warped by hot water. Cracks in the disc should be looked for, as they may cause it to break in service. The disc ball should be examined for swelling caused by hot water. The thrust roller hole should be checked for wear, because an oblong or badly worn hole provides a very loose bearing for the roller, causing a binding that results

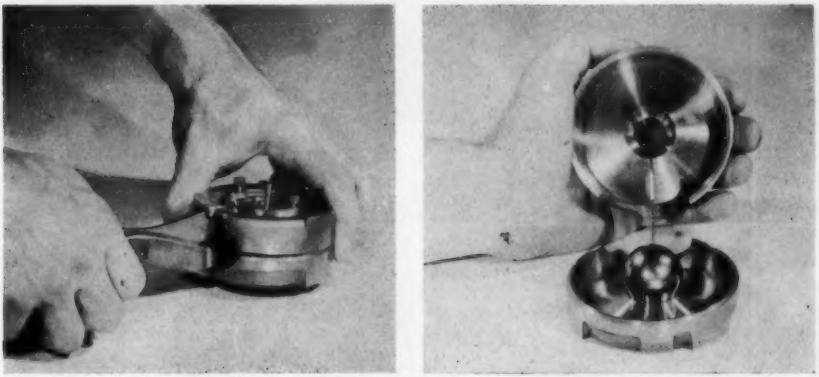


Fig. 9.2. Opening of Disc Chamber and Gaging of Chamber Ball Socket

A special prying tool (left) is here being used to open the split-case chamber. A metal ball gage (right) is used to check the socket for excessive wear.

in low-flow registration losses. It also leads to excessive wear in the thrust roller and chamber slot. The thrust roller should be inspected for wear and to make sure that it turns freely in the disc. A roller that cannot revolve properly will develop a flat spot on its head, causing a great deal of friction and unnecessary wear in the thrust roller slot of the chamber. Finally, the disc spindle should be examined for wear.

After badly defective or worn parts have been replaced, the disc should be inserted in the bottom of the chamber, and the chamber top placed in position and closed. To determine whether the disc has proper clearance, a new disc and chamber can be used for comparison. Without correct clearance, the meter will not give a good test result. If there is too much clearance, the chamber can be taken apart and, with the disc still assembled, a number of

Fig. 9.3. Examination and Assembly of Chamber and Disc

All parts should be carefully checked and replaced if worn.

pieces of brass shim stock, ranging in thickness from 0.002 to 0.007 in., may be placed under the disc ball, one by one, the chamber being closed in the usual manner after each trial. When a piece of the right thickness to give the proper clearance has been found, the disc may be taken apart for insertion of the shims between the half-balls and the disc plate. (Before disassembling, however, the exact position of the balls in relation to the plate should be marked with a pencil so that they can be replaced in the same way. Unless this precaution is taken, there may be a faulty fit because of the uneven wear on the balls and chamber socket caused by lateral thrust.)

In the insertion of the shim, consideration should be given to the likelihood of differences in wear. Thus, if the required shim thickness is found to be 0.005 in., an 0.003-in. shim should be placed between the bottom half-ball and the disc, with an 0.002-in. shim between the top half-ball and the disc.

Shimming

It may be well to describe briefly the proper way to perform the shimming operation. The shim is cut in the shape of a cross, and the center of the cross is laid over the center of the ball socket in the chamber. The weight of the ball, when placed on the cross, forces the shim stock to the bottom of the socket, causing the arms of the cross to turn up around the ball. This method avoids wrinkling or creasing of the shim, which would result in false readings. In view of the repair time required for shimming, it may often prove more economical to use new, oversize balls—or even new discs, complete with oversize balls—rather than shims. When a new disc is employed for this reason or because the old disc has been damaged beyond repair (by hot water, for example), discs with ball sets of various sizes should be tried until one with proper clearance is found.

On reassembling the disc and chamber, one should blow gently through the outlet port to test the freedom of movement of the disc. If it sticks, one should take hold of the top of the disc spindle and turn it counterclockwise for approximately 10–20 revolutions. Then the disc should be removed from the chamber and examined to see where it has been binding. This is indicated by highlights or shiny marks on the disc or ball. A nick in the finished surface of the chamber will cause the disc to hang up at that point. By using a three-cornered scraper or any sharp instrument, one can eliminate all obstructions. The disc and chamber may then be reassembled and checked again.

Another way to obtain a smooth fit for the disc is to use a grinding compound on the half-balls and disc edge and "run in" the disc by revolving the disc spindle. This method has been objected to on the ground that there is some danger of impregnation of the hard-rubber parts with the grinding compound, which even the most thorough rinse cannot remove. Under service conditions, the cutting action of the abrasive can cause excessive wear.

Gears

The gear train should run freely and mesh smoothly. All spindles should be checked for wear, and bushings for worn and oversize holes. They should be replaced if worn. All gear teeth should be checked to see if they are worn. If the gears revolve around the spindle, the hole in the gear may be worn. The control roller should be

checked to see if it is worn or badly swollen. It is very important to have a control roller of proper size, as the closer the fit to the disc spindle (without binding as it revolves), the greater the accuracy on fine flow tests. Also, the control roller must run freely on its pivot or bearing, or it will show a considerable amount of wear in a very short time. Flat spots on the roller are an indication that it is sticking.

The meter change gear should then be removed and its teeth examined. The stuffing box nut should be checked and the old packing discarded. If there is wear on the upper driving pawl or stuffing box spindle, they should be replaced. If excessive wear or corrosion is found, the manufacturer should be consulted. If the condition is caused by the composition of the water, the manufacturer or his metallurgist can suggest steps to be taken.

Reassembly

To reassemble the meter, insert the upper driving pawl spindle in the inverted main casing. Then screw the gear train in position, either in the casing or on top of the chamber, depending on the make of the meter. Lower the chamber into the casing, making sure that the bottom lugs of the chamber are flush with the gasket seat of the casing. Apply thumb pressure on the bottom of the chamber to place it in proper position. If the chamber does not fit snugly against the outlet port of the casing, some of the water will bypass the meter and registration will be very inaccurate.

Blow gently into the outlet port of the meter to check the freedom of movement of the disc and gear train. Insert a new bottom gasket in place and bolt the bottom in position, tightening alternate bolts a little at a time. Then set the meter in an upright position and repack it with new stuffing box washers. If possible, do this in a test machine. Before turning on the water and subjecting the meter to pressure, screw down the packing nut lightly. Turn on the water and adjust the nut until it stops leaking. (Making the stuffing box nut too tight will squeeze the spindle, causing a tremendous amount of friction and retarding registration of small flows.) With the pressure on the meter, let the change gear drop down on top of the stuffing box nut, lift up the gear slightly, and tighten the set screw. The upper driving spindle will thus be forced up by the pressure in the meter, representing the actual condition in the field. When the register is properly placed on the meter so that

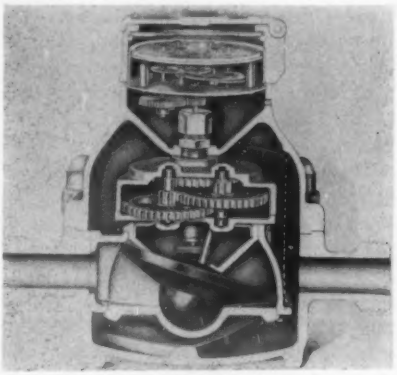


Fig. 9.4. Disc Meter With Three-Part Chamber

In this meter, as in most disc meters with three-part chambers, the disc can be removed by removing the bottom plate of the chamber. The disc and ball are one piece and cannot be replaced separately.

both gears mesh, they will at all times remain in their correct positions. If the meter gear were placed on the spindle in the down position and the register and gear set to mesh, water pressure might cause the spindle and meter gear to rise and become disengaged from the register gear and result in a dead meter.

If the register is undamaged but does not run freely, soaking it in penetrating oil and then in light lubricating oil may prove effective. If the register then runs freely, without too much play in the gears or wear in the bushing, it will not have to be disassembled and repaired. Register gears turn so slowly that there should not be excessive wear on gears, spindles, and bushings.

Summary

Some of the important points of nutating-disc meter maintenance and repair are summarized below:

1. Clean all meter parts thoroughly.
2. Make sure the gear train runs freely.
3. Check the action of the disc in the chamber before and after assembly in the main casing.
4. Remember that friction is just as detrimental to a meter as leakage.
5. Store meters away from steam pipes, hot-water lines, furnaces, and other sources of heat.
6. Use a new meter as a standard of comparison for tolerances and clearances.
7. Do not hesitate to call on the manufacturer and his staff for help.

Disc Meters With Three-Part Chambers

The three-part chamber (Fig. 9.4) generally houses discs of conical shape, which may be removed from the chamber by removing the bottom plate. Removing the top chamber plate is not generally necessary, as wear usually takes place on the outlet side of the bottom plate recess or on the outlet side of the ball. Frequently, the turning of the bottom plate a third of the way around will bring the test back to its normal accuracy. If, however, the desired correction is not accomplished, the disc or the bottom plate—or, in the event of severe wear, both—should be replaced. The diaphragm, or division plate, should be checked for wear and replaced if necessary, and care should be taken to see that it does not bind on the ball of the disc. Setting of the diaphragm can be done with a lead hammer or by holding a piece of hard wood against the bottom plate side. The disc should, of course, move freely in the reassembled chamber.

Unlike the disc of the three-piece, flat type, the one-piece, conical disc cannot be shimmed to offset the wear on the disc ball or ball sockets. Replacement of the disc or the chamber bottom plate has the same effect and can be done by an inexperienced man in a very short time.

The chamber should be carefully cleaned. If chemicals or acids are used properly, the machined surfaces will not be damaged, but the use of abrasives may well destroy the tolerances necessary for accurate registration, and unless the chamber is thoroughly cleaned and rinsed, the abrasive action will continue for quite some time.

Oscillating-Piston Meters

The maintenance and repair of oscillating-piston meters are similar to the maintenance and repair of nutating-disc meters. The only difference is in the repair of the measuring chamber.

Oscillating-piston meters, like disc meters, have three outer casings and three interior working assemblies. The outer casings are: the register box, sometimes referred to as a cap or bonnet; the upper shell, sometimes called a cover or main casing; the bottom plate, also known as a base or lower shell. The working assemblies are the register, gear train, and measuring chamber.

Cleaning

Meters brought into the shop for inspection should be completely disassembled. The outer casings, bottom plates, bolts, nuts, gear trains, and screws may be cleaned by sandblasting, acid or alkaline descaler baths, or wire brushing in water. The method used will be dependent on the number of meters to be repaired per day. Measuring chambers should not be sandblasted, as sandblasting destroys the machined surfaces on the inside. The chambers should be cleaned in acid baths only to remove scaling and verdigris that are difficult to remove with a wire brush. Acids, if used, should be mild enough not to etch the machined surfaces of the chamber. Plated chambers should not be dipped in acids, as acids remove tinned coatings. The inside of the chamber often takes on a greenish color, but the coating may be perfectly smooth and the disc may move freely. This discoloration should not be removed, as it is a protective coating that helps to avoid any further corrosive action.

Register Boxes

The register box requires little repair. Unless severely damaged by malicious intent or accident, it may need only a new glass or lid. Broken or stained glass is easily replaced by removing the glass-retaining spring or,

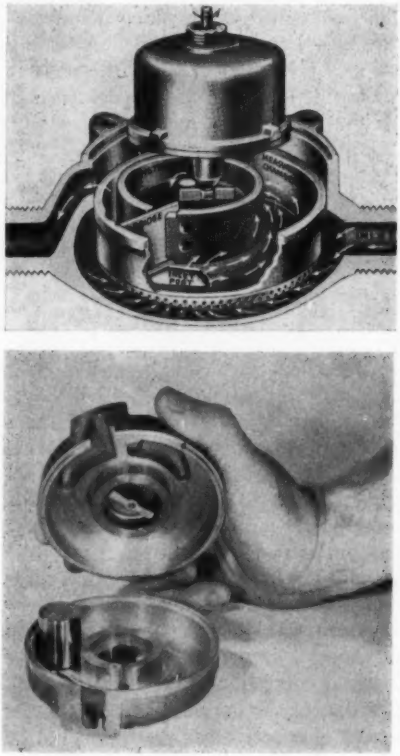


Fig. 9.5. Measuring Chamber of Oscillating Piston Meter

The measuring chambers of oscillating piston meters may be of the split-case type (lower) or removable-lid type (upper). In the lower illustration the chamber is being inspected with a gage for wear.

in the case of some old meters, the putty that holds it to the box. The new glass is placed in its proper position inside the box and the glass-retaining spring is replaced or the glass is reputtied. If the lid or serial number plate is bent or broken at the hinge, it should be replaced. To do this, the box should be placed in the vise and one end filed off the lid pin or rivet; the remainder of the lid pin should be driven out of the box with a small punch or icepick; then a new lid, new hinge pin, and rivet should be installed.

Upper Shells

The casing on ⅝-in.–2-in. meters is usually made of a bronze composition. Some types of meters have cast-iron upper shells on 1½-in. and larger sizes. Bronze shells should be checked for distortion caused by frost. This can be checked by placing a straightedge across the main flange to see if the surfaces are true. If sprung, the casing should be replaced. The flange should be cleaned of all gasketing material. This can be accomplished with a suitable scraper. The stuffing box horn on the top of the shell should be checked to see if the hard-rubber stuffing box spindle bushing is excessively worn. If worn, the bushing should be replaced. The bushing may be driven out with a suitable punch or drilled out. A new one should then be press-fitted into the horn. Some upper shells do not have integral stuffing box horns but have a hole through which the horn of the gear train protrudes. The top of this hole has a counterbore for a gear train locknut and should be thoroughly cleaned. The bottom of the hole has a faced boss against which rests a gear train gasket. This boss should be cleaned of all gasketing material. Cast-iron upper shells should be checked as described above, and for deterioration. Cast iron graphitizes with age. Graphitization lessens the strength of the casting. Where this condition exists the shell should be replaced. Graphitization can be checked by scraping the flange of the casting with a scraper or knife. If the metal powders like the lead on a pencil, graphitization is occurring. Iron casings, if reused, should be painted on the inside with an asphalt-base paint to protect the iron from corrosion.

Lower Shells

The lower casing is made of bronze or cast iron, depending upon whether the meter is the frost or nonfrost type. To check bronze lower shells for distortion caused by frost, place a straightedge across the main flange. Distorted casings usually cannot be reused and must be replaced. The flange should be cleaned of any gasketing material. The threads on the spuds should be checked. If threads are nicked or damaged, they may be made usable by running a rethreading die over them. Cast-iron lower shells should be checked for graphitization, as explained above for cast-iron upper shells. The cast-iron lower shell, if reused, should be painted on the inside with an asphalt-base paint or lined with a copper, brass, or plastic liner.

Registers

Round registers should be checked for loose hands, loose spindle wheels, worn bushings and pinions. After the hands and porcelain face have been removed, the register may be dipped in acid to clean it. If dipped in acid, the register should be flushed with cold water. If none of the spindles, pinions, or wheels have to be replaced, it will

not be necessary to take the register apart. The register can be dipped in kerosene or an anticorrosion oil. This will counteract any remaining acid and also lubricate the register. The register face should be replaced if cracked or if the numerals are faded. Finally, the hands can be replaced and resoldered.

Gear Trains

Gear trains of the open or enclosed types should be completely disassembled. The wheels, pinions, and spindles should be checked for wear and

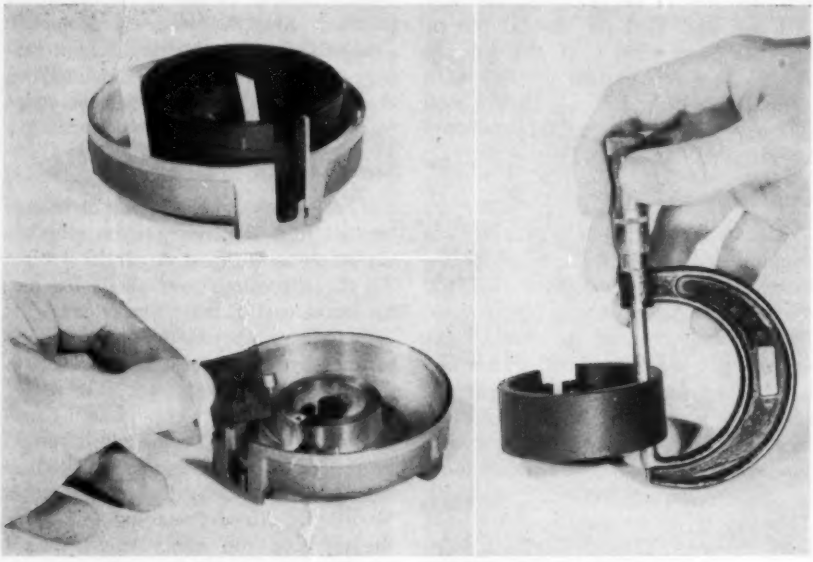


Fig. 9.6. Gaging and Inspection of Bridge, Piston, and Chamber

Each of the parts of the measuring chamber assembly should be carefully inspected. In the right photograph, a micrometer is being used to check for piston wear.

Straight registers should be checked for loose test hands, worn worms and worm wheels, cracked end plates on numeral wheels, bent main and tumbler shafts, and broken tumblers (sometimes referred to as mangled pinions). Unless disassembled, the register should not be dipped in acid, as acid will fade or eat the black ink on numeral wheels. If the register is not taken apart, it may be dipped in kerosene to clean, then flushed with cold water and lubricated with a fine oil.

replaced if necessary. The hard-rubber bushings in the top and bottom plates should be checked for wear. If excessively worn, they should be replaced. The holes in the bushings can be checked for wear by using the spindle in a new wheel as a guide. The holes can also be checked with the shank of a drill of the same diameter as a new wheel spindle. Hard-rubber bushings can be removed readily by three methods. The method

used depends upon the number of gear train plates to be rebushed.

1. Drill out the bushing with a drill one size smaller than the hole in the plate. Remove the remaining material with a small pick. (An icepick will do.)

2. Extract the bushing with a bushing extractor made by the manufacturer or made by holding a proper-size wood screw in T-handle tap wrench. The wood screw should be slightly larger than the hole in the bushing. The head will have to be ground off the wood screw so that it can be held by the tap wrench.

3. When large quantities of plates are to be rebushed, time can be saved by placing the plates in a pail of hot water for several hours. Hot water expands the metal around the bushing and allows the bushing to drop out or be picked out easily.

New bushings are press-fitted into place and should be staked to keep them from turning. Staking can be done with a regular staking tool or with a center punch. After the holes have been staked in, the bushings may have to be reamed. A drill one size larger than the gear spindle may be used as reamer. Worn driving dogs on the top and bottom of the gear trains should be replaced.

Measuring Chambers

Unlike disc chambers, oscillating-piston chambers have no curved inside surfaces. The piston design and the large flat areas over which the piston glides restrict chamber and piston wear to a minimum even after many years of service.

Chambers are made in three styles, namely, two-piece three-piece, and split-case (Fig. 9.5). Two-piece chambers consist of a chamber with removable top or bottom head. Split-case chambers consist of two chamber halves, snap-fitted in the middle. Three-piece chambers consist of a cylinder ring with removable top and bottom heads. Regardless of design, these chambers contain a division plate (sometimes called a bridge), a piston, and a piston roller.

The fitting of pistons to these three styles of chambers is the same. To examine an old piston for wear (Fig. 9.6), shim stock, thickness gages, or tissue paper, approximately 0.001-, 0.003-, and 0.005-in. thick may be used for the $\frac{5}{8}$-in. size. The 0.001-in. shim is placed between the piston web and the top and bottom chamber abutments. The 0.003-in. shim is placed between the top of piston rim and face of chamber. The 0.005-in. shim is placed between the outside of the piston and the inside of the chamber wall. Excessive clearances usually indicate piston wear. A new piston will close up excessive clearances. The new piston should be checked with these shims. The sidewall of an old piston should be checked with straightedge to determine if it has been distorted by heat. The piston should also be examined at the division plate slot. This slot has two V-shaped surfaces opposed to each other (><). If V edges are worn excessively, the piston should be discarded. Examine the division plate. If either wall is worn or severely scratched, use a new plate. Examine the piston roller for roundness. If flat areas are apparent on the cylinder, replace it. Whenever a new piston is used to repair the chamber, use a new piston roller. To reassemble, place the division plate in the chamber. In some styles of chambers, the division plate is press fitted into slots in the chamber wall and center

abutment. This press fitting should be done by hand. Do not drive the plate in place with a hammer, as this will probably distort the chamber wall. If the division plate does not slip in position with the pressure exerted by the thumb, then file the edges of the division plate until it slip-fits. Place the piston roller on its spindle in the chamber. See that roller turns freely. If not, polish the roller spindle with a crocus cloth. Place the piston in the chamber and check the clearances with shims. Oscillate the piston through its cycle very slowly. If the piston sticks or hangs up during its cycle, the trouble can usually be found in the piston slot or piston loop. Check to see that the piston slot V sections (><) are not bearing too tightly on the division plate. If too tight, gently file the flat area of the V sections. This will open up the slot and allow greater clearance for division plate. Also check the loop of the piston which is below V section to see that it does not bear on inner edge of division plate. If it bears too tightly, the piston loop will be polished where it strikes the division plate. Remove the polished area with a scraper or a small, half-round file. Place the chamber head on the chamber and again oscillate the piston slowly through its cycle. If the piston still sticks or hands up, it is probably due to the height of the piston. Remove the chamber head and piston and note any polish marks on the top or bottom rim of the piston. Remove the polished area. This can be done by laying a sheet of crocus cloth on a flat surface and rotating the polished side of piston on the cloth until the polished area is removed. A properly fitted piston will oscillate through its cycle with a minimum of applied pressure. The sensitivity of its motion may be tested by holding the chamber in a vertical position and turning it clockwise. The piston, if properly fitted, will always remain on, or readily return to, the bottom. The three working assemblies, after repair, are now ready to be installed in the casings. Always use new casing gaskets and stuffing box packing when reassembling the meter.

Chapter 10—Layout and Equipment of Maintenance Shop

MANY water utility men are faced with the task of laying out a new meter testing shop or improving the arrangement of an old one. The numerous advantages of the use of proper equipment, well located in the space available, justify careful study and planning. The following suggestions on what to use and where to place it may be of some help.

Meter shops range in size from those for repairing and testing a few dozen meters a year to some which work on more than 10,000 meters annually. In addition to the number of meters, other conditions that can affect the size, equipment, and layout of the shop include:

1. Number of makes and types of meters used, which governs the size of the repair part stock and the storage space for it

2. Local water quality, which determines the extent of corrosion, liming, incrustation, and wear

3. Location and type of meter settings, which control the condition of the meter register and the outside of the casing (The repair of frozen meters is a tremendous job in certain meter shops; in other localities, meter casings become caked with mud, and, when the dial glass is broken, the entire register may be clogged with mud.)

4. Local practice or state requirements specifying how often meters shall be tested

5. Customer ownership of meters, which calls for special care in identifying and segregating meters so that they can be returned after testing

6. Existence of special cleaning practices in refurbishing meter casings during the process of repair and testing. (Whether done by wire brushing, acid dipping, sand blasting, or painting, special equipment is required.)

In planning the equipment and layout of any meter shop, some or all of these factors must be borne in mind. Possibly more important than any of them is the trend toward increased numbers of meters and toward more frequent repairs as they become older. All planning should be done with an eye to the future.

Selection of Equipment

The basic equipment, exclusive of a desk or file for meter records, is listed below. The most essential items are given first, followed by those that would be justified only in large shops:

1. An accurately calibrated tank, or a plain tank on an accurate scale, to check the meter being tested against the actual volume causing a given registration (Drainage piping for the tank, or tanks, should be of sufficient size to empty it quickly.)

2. A substantial workbench with a vise, hammer, wooden or leather mallet, screwdrivers, wrenches, pliers, files, scrapers, wire brushes, and other tools

3. A sink with running water, preferably both hot and cold, for washing meters and parts

4. A test bench for domestic-size meters (1 in.) or smaller (Although meters can be connected with ordinary fittings, there is a saving in time and effort if a test bench is used for smaller meters, which probably constitute up to 99 per cent of the total tested. The number of test units on the bench is governed by the volume of work. Series testing is generally economical. For more efficient testing, benches may provide for hydraulic clamping of meters and automatic shutoff of flow at the proper tank level.)

5. A rate-of-flow indicator

6. An electric grinder, with wire brush and buffer, which has a wide variety of uses

7. Storage bins or drawers for meter parts

8. An adapter for testing 1¼-, 1½-, and 2-in. meters (This accessory, which can be attached to the test bench, provides ease of testing of larger meters at a minimum investment.)

9. A small air compressor (Only experience can indicate the many ways in which compressed air is convenient for cleaning, drying, painting, and similar operations.)

10. A bench drill press or an electric hand drill, a widely useful device (Electrical outlets should be conveniently located.)

11. Chemical cleaning equipment (Experts disagree greatly on the advisability of using acids or other chemicals on meter parts. The cleaned pieces, especially when treated with acid, have a fine appearance but may be slightly reduced in size, so that meter performance is affected. When chemical cleaners are used, precautions must be taken to prevent health hazards. Proper rinsing facilities and exhaust fans should be provided.)

12. A test bench for 1¼-, 1½-, and 2-in. meters (When enough large meters are to be tested, a special bench for one or more of them is a good investment. Calibrated tanks large enough to hold water for tests run at high rates of flow are also desirable for quantity testing of large meters.)

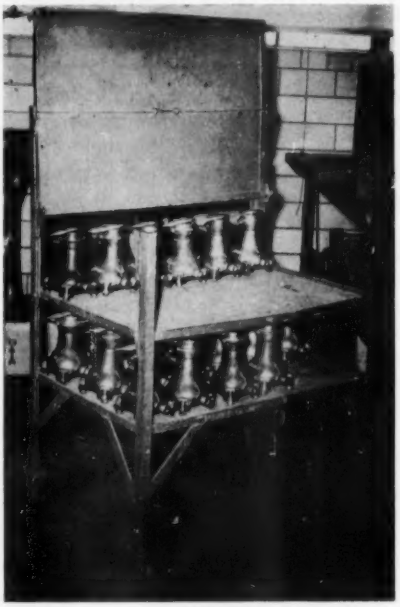


Fig. 10.1. Cart for Moving and Storage of Meters

Carts such as the one shown above are useful not only in saving steps but if a specified number of meters is kept on each such cart, it can greatly simplify inventory counting.

13. An electric or air-driven impact wrench. (This facilitates speedy removal of large meter casing bolts.)

Lack of equipment need not result in poor testing of small meters. With an accurate tank, a watch, and a few valves and fittings, it is possible to do a thorough testing job. Some or all of the additional items listed above will, however, increase efficiency and are usually a good investment.

Shop Layout

After the amount and type of equipment to be included in the meter shop have been decided upon, attention should be given to proper placement in the allotted space. There are a number of requirements to be satisfied and a good many valuable principles to be applied. The arrangement adopted should provide the best flow of meters through the shop. The distance between adjacent stations should be short, and easy methods of moving the meters should be available.

A meter follows this general routing in the shop: the incoming meter is tested and stored; next, it is washed and disassembled; the parts are cleaned, nonserviceable parts are replaced, and the meter is reassembled; then it is taken to the test bench and given the required tests; if its accuracy is within the limits prescribed, it is sent to outgoing storage; if further repair is necessary, the meter is returned to the repair bench, and part of the cycle is repeated.

The nature of this cycle suggests the necessity for good materials-handling practice to simplify as much as possible the physical work. This objective can be approached by:

1. Locating the meter shop on the ground floor, which eliminates elevators and speeds up supply

2. Arranging for a loading dock near the door of the meter shop, which also will shorten the distance supplies must travel

3. Maintaining good lighting, either natural or artificial, throughout the shop (Work tables should be arranged so that the light from the windows does not shine into the repairman's eyes. Good operation in a meter shop depends upon the ability of the workmen to see what they are repairing, inspecting, or testing.)

4. Providing for both hot and cold running water (Washing meter parts with hot water and soap is the least harmful method in use and is sufficient for many parts. Hot water is essential, especially in cold weather.)

5. Locating a motor-driven buffer near the repair bench (It is important to have this machine within a very few steps of the repairman, to obviate continual walking. The buffer should be equipped with a dust collector or exhaust.)

6. Washing the exterior of dirty meters when they begin the processing cycle (This practice will improve working conditions by producing a much cleaner meter shop.)

7. Making compressed-air hoses available to both the repairman and the meter tester

8. Providing storage space for both incoming and outgoing meters near the door (There they can be easily counted and readily moved in or out.)

9. Placing the meter record file near the door and the meter storage area

10. Keeping commonly used parts on the repair bench and storing other parts nearby for easy access

11. Avoiding extensive paperwork in the parts checkout procedure (Time will be saved and the repairmen will be appreciative.)

12. Equipping the shop with carts (Fig. 10.1) or rolling racks to be used

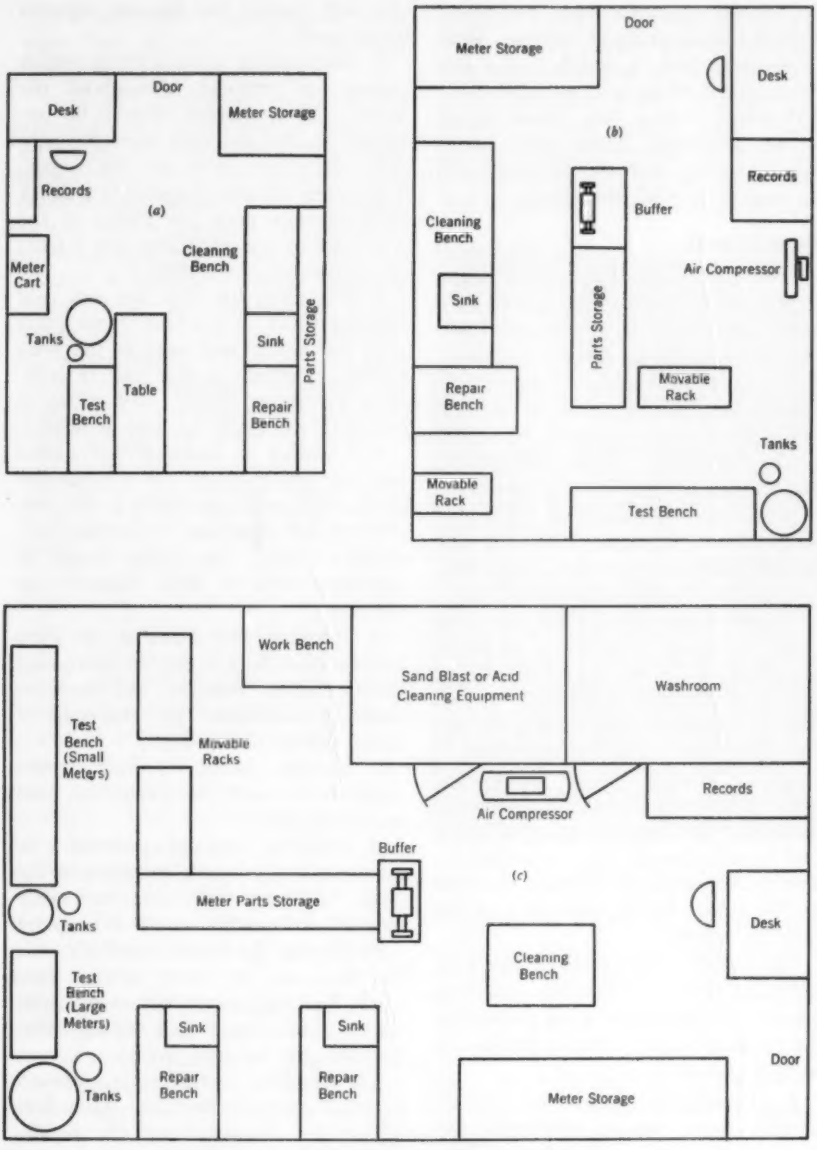


Fig. 10.2. Three Suggested Shop Layouts

Key: (a) *12 × 15 ft;* (b) *15 × 20 ft;* (c) *20 × 30 ft.*

for moving meters from one station to another and for storing meters (Each rack or cart should hold a specified number of meters so that quick inventory can be taken. It should be easy to reach every meter and read its tag. In a small shop, ten meters per cart would be enough; in a large shop, 100 meters arranged on a rack would be more efficient. It may be desirable to provide facilities for hooking meters on the rack in a vertical position. With the processing cycle is worth serious consideration.)

It is usually impossible to adhere closely enough to theory to produce the ideal layout, chiefly because existing facilities impose limits upon the designer. It is less expensive to work such facilities into a layout than to alter them to fit. It may, however, be worthwhile to compare the cost of changing the existing facilities with the value of the increased efficiency. The

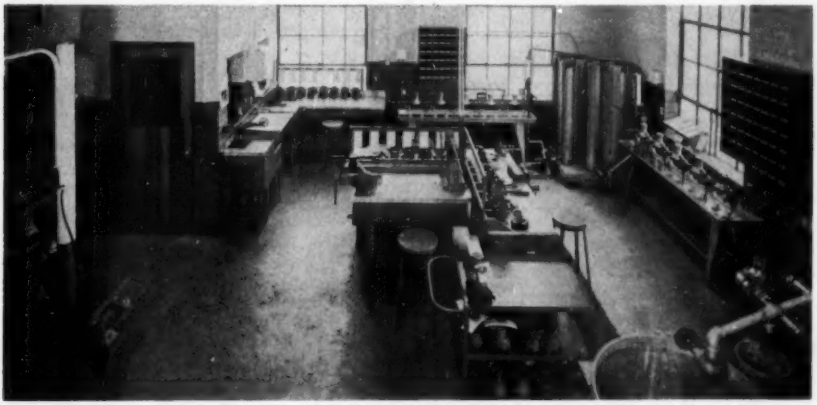


Fig. 10.3. View of Efficient Meter Shop

The storage racks are visible in the left foreground, with the grinder and buffer a little to the right; at rear left is the acid cleaning room, flanked by a sink and workbench; test benches and tanks for small meters are at rear right; in the right foreground, part of the large-meter testing equipment can be seen; at center are other workbenches, with a portable rack for small meters in front of them.

that system, each meter is on the outside of the rack and can be removed or examined without disturbing any other. Dock facilities can be arranged so that an entire rack filled with meters can be rolled alongside a truck for loading, thus eliminating one handling operation. The benefits from mobility of meters should not be underestimated; any practice that will speed up features affecting meter shop design include: shape and size of room; existing piping; location and size of windows, doors, and columns; size of available equipment, such as filing cabinets and workbenches; and availability of storage space for meter and parts outside the room. The latter condition can be an advantage if there is not enough space inside the room

for storage. Otherwise, to have the storage in another room means wasted steps every time a part of a meter is moved.

The three suggested layouts illustrated in Fig. 10.2 demonstrate the principles mentioned previously. The larger cities, the arrangement in Fig. 10.2 (*c*) provides for two separate repair benches, two test benches (one for smaller meters and one for meters larger than 1 in.), a cleaning room, and a washroom. Movable racks are shown in all three layouts. An actual

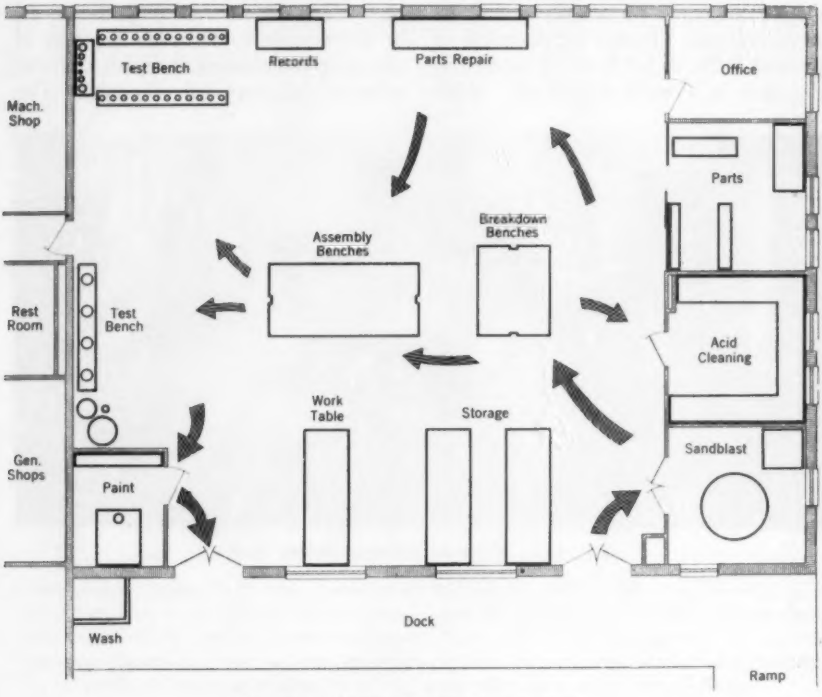


Fig. 10.4. Meter Repair Shop Layout

Arrows indicate the order of a typical repair process.

prevailing conditions determine the layout. In the small-shop layout in Fig. 10.2 (*a*) the meters move clockwise about the room with only short distances between adjacent stations. The layout in Fig. 10.2 (*b*) provides more storage space, a buffer, more bench space, and a larger test bench. For layout is shown in Fig. 10.3 and another floor plan is diagrammed in Fig. 10.4.

Meter shop layouts that embody the principles of efficient material handling, have proper equipment, and adequately provide for the workman's needs can definitely save time as well as labor.

Chapter 11—Meter Records

A SUITABLE record of meters is one that provides full and complete information on the installation, repair, and testing of each meter with a minimum of expense. The time and effort devoted to maintaining meter records are considerable, at best, because of the number of units involved, and because meters, unlike other items of water works facilities, do not remain at one location during their useful life but are frequently moved.

Any system of meter records should provide such basic data for each meter as size, make, type, date of purchase, where the meter is located at all times, and data on all tests and repairs. One method for maintaining such records is by use of a meter history card (Fig. 11.1). The basic meter data are inserted at the top of the form, and the remainder is designed to record its various installations and test and repair work in chronological order. Each line of the test and repair record section is divided into two segments, the upper being used to record the test results for the meter upon its removal from service and the lower half to record the final test results before the meter is reinstalled. These meter history cards are filed in numerical sequence, either by the manufacturer's serial number or the utility's number, if the utility has its own system of meter numbers.

Although this method of maintaining meter records is a good one, it requires transcribing much detailed information from other primary records. The work involved might be compared, for example, with that of a system composed of the following forms:

1. Service order
2. Service envelope
3. Meter envelope
4. Report of meter tests and repairs.

It is necessary to describe this system in more detail to show how a great deal of duplication is eliminated without sacrifice of any meter data.

Service Order

The service order (Fig. 11.2) is prepared, usually by the commercial department, and authorizes the work to be done. Regardless of origin, a service order is used to cover all types of work involving the installation, removal, or change of meters. Upon completion, the installation or removal data of meters are first posted to that meter's meter envelope. In addition to this posting, for each meter removed from service, a report of meter test and repairs is prepared from data furnished on the service order. After these two records are posted, the service orders are turned over to the commercial department for further processing. Finally, when all records are posted, the service orders are filed in the service envelopes.

Service Envelope

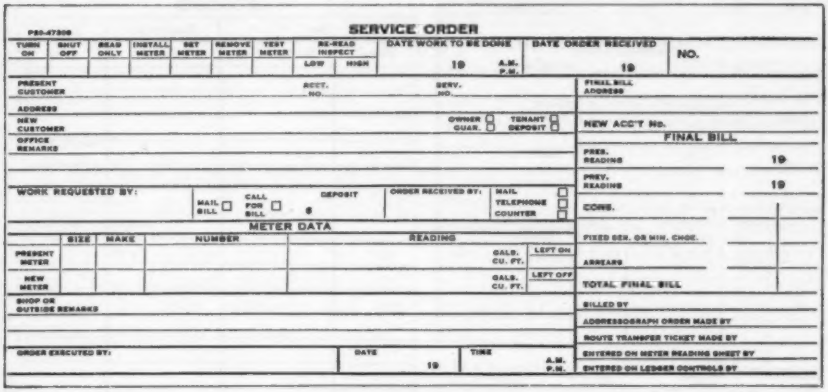
The service envelope is an envelope of suitable size to hold all records concerning particular service location served. As each new service is in-

MFR. No.				CO. No.				MAKE						SIZE			
DATE PURCHASED				COST				STYLE									
INSTALLATION RECORD								TEST AND REPAIR RECORD									
Installed		NAME	ADDRESS	Tap No.	Reasons for Removal	Removed		Date	Rate of Test			Repairs		Total Amt. of Water Passed Before Test	Tested By	REMARKS
Date	Reading					Date	Reading		Min. Flow	Inter. Flow	Max. Flow	Before Test	After Test			

Fig. 11.1. Meter History Record

This kind of meter record, though it contains all pertinent information and is convenient for reference, necessitates much unnecessary paperwork, in that it is compiled from innumerable small records.

stalled, a service number is assigned to it and recorded, in addition to the meter route and account number. The service number is never changed, being used for permanent identification of the service location. A service envelope is made out for each service. It has an ungummed label and the assigned service number is stamped on the outside. All records pertaining to that particular property are filed in the service envelope. These include the original order to install the service, which, of course, shows all materials used in making the service and meter installation, together with measurements of service location and other data. All service orders for the property, all correspondence, and all other data are also filed in the service envelope.



SERVICE ORDER

P80-47306

TURN ON | SHUT OFF | READ ONLY | INSTALL METER | SET METER | REMOVE METER | TEST METER | RE-READ INSPECT: LOW / HIGH | DATE WORK TO BE DONE 19 A.M. P.M. | DATE ORDER RECEIVED 19 | NO.

PRESENT CUSTOMER — ACCT. NO. — SERV. NO. — FINAL BILL ADDRESS

ADDRESS NEW CUSTOMER — OWNER ☐ GUAR. ☐ TENANT ☐ DEPOSIT ☐ — NEW ACCT NO.

OFFICE REMARKS — FINAL BILL

PRES. READING 19

PREV. READING 19

WORK REQUESTED BY: — MAIL BILL ☐ CALL FOR BILL ☐ DEPOSIT $ — ORDER RECEIVED BY: — MAIL ☐ TELEPHONE ☐ COUNTER ☐ — CONS.

METER DATA

	SIZE	MAKE	NUMBER	READING		
PRESENT METER					GALS. CU. FT.	LEFT ON
NEW METER					GALS. CU. FT.	LEFT OFF

FIXED GEN. OR MIN. CHGE.

ARREARS

TOTAL FINAL BILL

SHOP OR OUTSIDE REMARKS

BILLED BY

ADDRESSOGRAPH ORDER MADE BY

ROUTE TRANSFER TICKET MADE BY

ENTERED ON METER READING SHEET BY

ENTERED ON LEDGER CONTROLS BY

ORDER EXECUTED BY: — DATE 19 — TIME A.M. P.M.

Fig. 11.2. Service Order

This form, usually prepared by the commercial department, authorizes work to be done. After posting of pertinent information from this form onto other records in the maintenance shop, it is returned to the commercial department for processing.

Meter Envelope

A meter envelope (Fig. 11.3, right) is prepared for each meter on the date of purchase, and the dates of installation and removal of the meter are posted to this envelope from service orders. Dates of tests of the meter are posted to this envelope from the report of meter test and repair, and each envelope is used to hold all such reports for the particular meter. These are the the only data placed in the meter envelope. Particular attention is called to the fact that the only identification of the premises in which the meter is installed is the service number. If the actual location is required, reference can be made to the service envelope for the original primary record of installation (and removal) for a complete record—that is, name, address, account number, reason meter was installed or removed, who did the work, and readings. Use of the service number as a means of identifying meter location reduces posting work considerably without loss of any necessary information. Furthermore, filing of the original reports of meter repairs and tests in the meter envelopes also eliminates a great deal of work, as only dates are posted.

Report of Meter Test and Repairs

As previously explained, a report of meter test and repairs (Fig. 11.3, left) is made out from service orders for each meter removed from service. As 95 per cent or more of all meters in a system are ⅝-in. size, rubber stamps are used to prepare a supply of these reports for ⅝-in. meters in advance of need, which further reduces posting

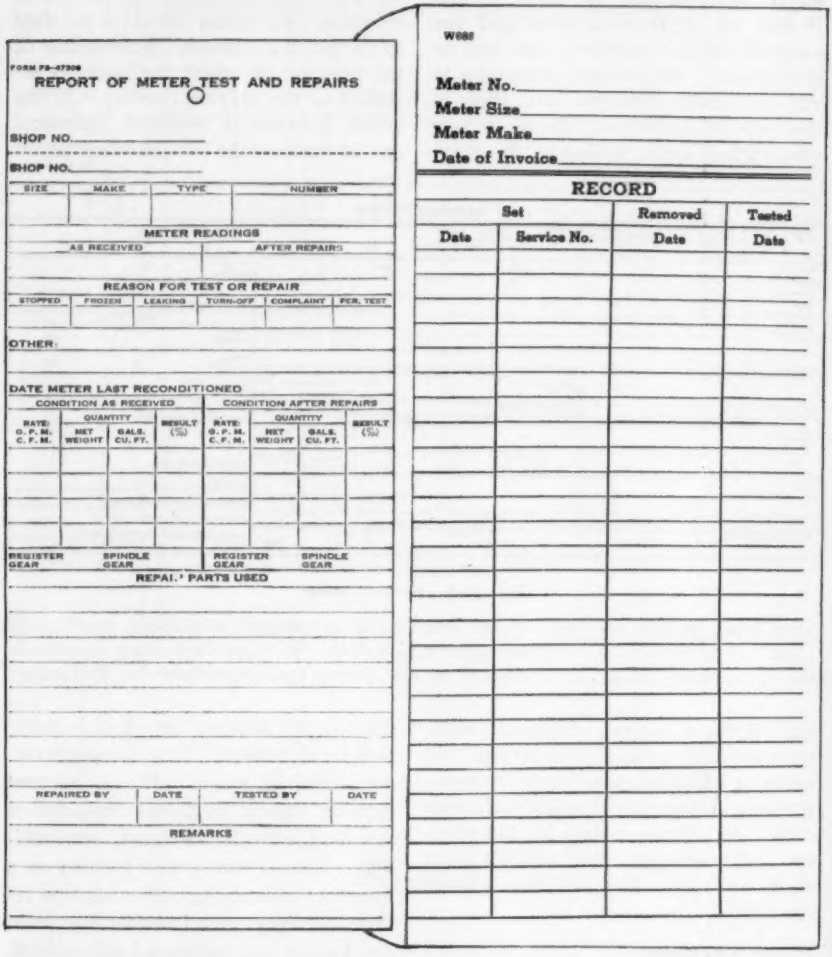


Fig. 11.3. Report of Meter Test and Repairs, and Meter Envelope

These records, kept in the maintenance shop, contain all data needed by those directly concerned with the installation, repair, and removal of meters.

work. One of these stamps is designed to imprint the meter size (⅝-in.), make, and type (disc) in the spaces provided. The other stamp prints the various rates of flow, and quantities of water used in testing ⅝-in. meters. Therefore, when a ⅝-in. meter has been removed from service, it is necessary only to write in (from the service order) the meter number and check the reason for removal. The reading of the meter is not transcribed from the service order but is posted as an independent reading by meter shop personnel. Here, again, it will be noticed that all information of assistance to the meter shop personnel is furnished, but no extraneous data.

Summary

1. Service envelopes contain all data with respect to a property, including service orders.

2. Service orders contain the detailed data of meter installations and removals for each property and are filed in the service envelope.

3. Meter envelopes contain the history of each meter. The installation and removal record is posted from service orders. Dates of meter tests are posted from reports of meter tests and repairs. Actual repair data are obtained from the reports filed inside the meter envelope.

Although there are innumerable systems of meter records, many of which may be considered better than the one described, this particular system is one that provides all pertinent information and does so with a minimum of effort. A review of almost any system of meter records will reveal unnecessary duplications or more elaborate and detailed records than are required. A little time and effort devoted to this problem may well result in elimination of a large amount of clerical work with only slight changes in the system or method. At least, a review will show whether or not current methods are being followed simply because "It's always been done that way."

Minford Silt and Ground Water Quality in Western Ohio

Stanley E. Norris

A contribution to the Journal by Stanley E. Norris, District Geologist, USGS, Columbus, Ohio. Publication of this article has been authorized by the director, USGS.

THE Minford silt, a lacustrine deposit which fills the lower part of many preglacial valleys in Ohio, is a common source of trouble to well drillers and has caused several drilling failures in the western part of the state. The Minford, which in most places is clay rather than silt, is difficult and sometimes impossible to drill with ordinary churn equipment. This is especially true where the fine-grained material is saturated with water under strong artesian pressure, which forces the silt upward into the well casing as the well is being deepened. Most experienced drillers, when drilling in buried-valley areas, make strong efforts to develop wells at relatively shallow depth in the glacial drift, above the Minford silt.

Possible Advantages

The Minford silt may not, however, be a total liability in ground water development. Indeed, if the hypothesis presented later in this article proves to be correct, areas that overlie the Minford silt may someday be sought out by representatives of industries or municipalities that are looking for sites to develop wells. The aforementioned hypothesis stems from recent discoveries made in the course of a USGS water resources investigation (*1*) in Madison County, Ohio, made in cooperation with the Division of Water, Ohio Department of Natural Resources.

The newly acquired evidence points to the possibility that the Minford silt may, under certain conditions, significantly reduce the hardness of ground water in a limestone terrane. If this is true, it may point the way to substantial future savings in water treatment costs, if wells are so located as to take advantage of this natural softening process.

The Minford silt is a finely laminated clay, laid down in the valleys of north-flowing streams when these streams were dammed by an early glacier (*2*). The clay minerals in the Minford silt consist of well crystallized illite and chlorite (*3*). According to Grim (*4*), these minerals have significant ion-exchange capacity. Ion exchange, however, does not account for all the chemical changes believed to take place in the ground water in Madison County.

Natural Softening

Evidence of natural water softening, thought to be produced by the Minford silt, and an illustration of the resultant saving in the cost of treatment, are found at London, the county seat of Madison County, about midway be-

tween Columbus and Dayton. At London, a sand and gravel aquifer overlying the Minford silt yields water significantly softer than water from both a shallower aquifer and a deeper aquifer in the same area. London and the nearby London Prison Farm are near the axis of the buried preglacial Teays Valley, whose course passes in a wide arc to the east, north, and west of the city. Both the town and the and gravel aquifer. Water in the first wells drilled into the lower aquifer at London rose to a height of 20 ft above ground level, showing that the head, if it originates in the limestone, is high enough to cause a considerable quantity of water to flow upward through the Minford silt. As the water comes in contact with the Minford silt, its hardness evidently is reduced.

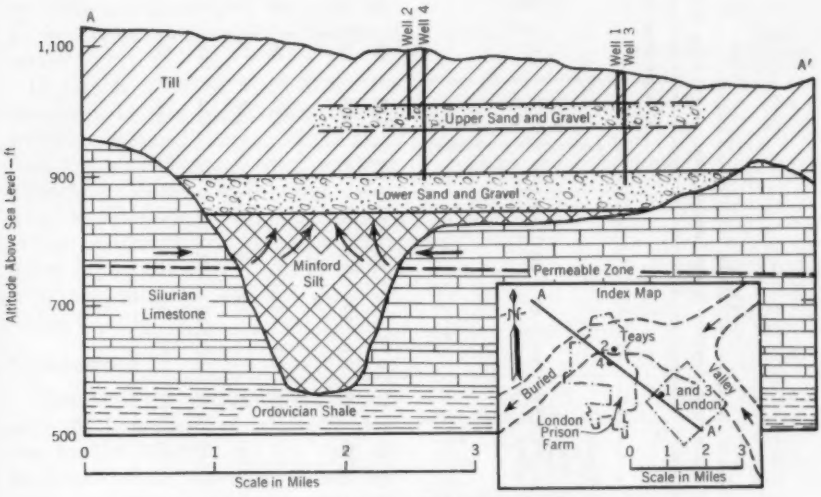


Fig. 1. Generalized Geologic Cross Section at London, Ohio

The flow of ground water (indicated by arrows) takes place from a permeable zone in the limestone, through the Minford silt, and into the lower sand and gravel aquifer.

prison farm get their water supplies from wells drilled into two sand and gravel aquifers, the lower of which lies directly on the Minford silt and is believed to receive recharge principally from the limestone beds on the flanks of the buried Teays Valley (*1*). As shown in Fig. 1, water moving from permeable zones in the limestone is believed to pass upward through the Minford silt into the overlying sand

Comparative Analyses

Effects of Minford silt on the composition of ground water are shown in Table 1, in which the chemical quality of water in the lower aquifer may be compared with that of water in the upper sand and gravel aquifer and that typical of the underlying limestone at the nearby villages of South Solon and West Jefferson. The results of the

TABLE 1

*Analyses of Water from Aquifers in the London Area, April–May 1957**

Sample Source	Depth *ft*	pH	Color	Specific Conductance at 25°C *μmhos*	Concentration—*ppm*												Hardness as $CaCO_3$	
					SiO_2	Fe	Ca	Mg	Na	K	Bicarbonate as HCO_3	SO_4	Chloride as Cl	Fluoride as F	NO_3	Dissolved Solids†	Ca and Mg	Noncarbonate
Upper sand and gravel																		
Well No. 1	78	7.5	3	787	17	0.79	94	44	23	1.1	445	69	8.0	0.6	0.0	509	416	51
Well No. 2	110	7.8	2	795	19	2.6	107	42	23	1.3	465	94	2.8	1.0	0.1	530	440	58
Lower sand and gravel																		
Well No. 3	172	7.8	1	733	18	1.1	81	37	30	1.4	457	46	2.2	1.0	0.1	462	368	0
Well No. 4	201	7.8	1	700	16	1.2	74	36	33	1.2	448	35	2.6	0.8	0.1	432	338	0
South Solon‡	179	7.6	1	1,110	14	2.0	125	52	63	1.1	478	258	4.4	0.4	0.1	786	532	140
West Jefferson‡	100(?)	7.1	2	886	13	0.52	98	50	26	2.3	440	120	12	1.2	0.6	565	450	90

* Analyses by USGS.
† Residue on evaporation at 180°C.
‡ Well in limestone.

analyses show that the hardness of the water in the lower sand and gravel aquifer averages about 75 ppm less than that of the water from the upper aquifer and about 140 ppm less than that of water from the nearby wells in limestone. If the lower hardness of the water in the lower sand and gravel aquifer is produced by contact with the Minford silt, the chemistry involved in this natural treatment process must be rather complex, as shown by differences in both cationic and anionic constituents and in dissolved solids.

In efforts to learn more about the chemistry of this hypothetical natural softening process, a sample of the Minford silt was obtained from southern Ohio and saturated with water taken from a limestone well at the nearby village of Plain City. Analyses of the water before and after it was in contact with the Minford silt are given in Table 2.

Conclusions

Results of the analyses seem to support the hypothesis of natural softening by the Minford silt, in that the hardness of the limestone water was reduced by 68 ppm during contact with the Minford silt. Changes in some other constituents, however, are not similar to those believed to take place in nature. For example, the sulfate content of the limestone water showed an increase after contact with the silt, whereas water from the lower aquifer at London contains notably less sulfate than water from nearby limestone wells. The same is true of calcium, which also increased slightly in the laboratory tests. Doubtless, some of the anomalous chemical changes are attributable to differences between laboratory and field conditions. The sample of Minford silt was from a weathered exposure, and undoubtedly was chemically different from the buried clay at London. Laboratory conditions of temperature, pressure, time, and mode of contact between the Minford silt and the limestone water clearly were different from conditions in nature.

TABLE 2

Effect of Addition of Minford Silt to Water From Silurian Limestone, Plain City, Ohio, Sep. 17, 1958*

Item	How Analyzed	
	As Collected	After Addition of Minford Silt
pH	7.2	7.8
Color	2	40
Specific conductance —*μmhos*	1,000	1,070
	Concentration—*ppm*	
SiO_2	13	14
Fe	0.04	0.13
Mn	0.04	0.08
Ca	122	124
Mg	58	47
Sr	32	8.8
Na	19	55
K	3.6	6.8
Bicarbonate (as HCO_2)	433	414
CO_2	0	0
SO_4	246	276
Chloride (as Cl)	11	14
Fluoride (as F)	1.0	1.0
NO_2	0.1	0.5
Dissolved solids		
Total	719	751
Residue†	696	724
Hardness (as $CaCO_3$)		
Ca, Mg, and Sr	581	513
Noncarbonate	226	174

* 400 ft deep.
† After evaporation at 180°C.
‡ 500 g was added to 3 liters of sample, which was then stirred for 2 days and filtered.

More data, some collected in other areas where geologic conditions are similar to those at London, obviously are needed to define clearly any effects on water quality produced by the Minford silt. London water utility officials, who are concerned with the cost of treating nearly 0.5 mgd, can attest to the potential value of such an investigation. At London the difference in treatment cost between water from the upper aquifer and water from the lower sand and gravel aquifer could amount to as much as $11,000 per year. The difference in treatment cost between this water and water from the underlying limestone could be even higher. This estimate is based on figures given by Larson (*5*), who stated that the cost of softening water by municipalities typically ranges from 27 cents per 1,000 gal, for water having a hardness of 340 ppm, to 20 cents per 1,000 gal for water having a hardness of 250 ppm. The difference in cost represents a rate of nearly 8 cents per 1,000 gal for each 100 ppm of hardness in the indicated range.

It is evident that much money can be saved by taking advantage of such natural softening as is believed to occur at London. The potential saving is enough to justify the cost of collecting additional data to determine whether the Minford silt does indeed act as an important natural softening agent.

References

1. Norris, S. E. The Water Resources of Madison County, Ohio. Bulletin of the Ohio Dept. of Natural Resources (in press).
2. Stout, Wilber & Schaaf, Downs. Minford Silts of Southern Ohio. *Bul. Geol. Soc. Am.*, **42**:663 (1931).
3. Norris, S. E. & Spicer, H. C. Geological and Geophysical Studies of the Preglacial Teays Valley in West-Central Ohio. USGS Water Supply Paper 1460-E (1958).
4. Grim, R. E. *Clay Mineralogy.* McGraw-Hill Book Co., New York (1953).
5. Larson, T. E. Municipal and Home Water Softening. *Jour. AWWA*, **45**:557 (Jun. 1953).

Corrosion Inhibition With Sodium Nitrite

Jess Beecher, Charles Dinkel, and Steve Corwin

A contribution to the Journal by Jess Beecher, Director of Tech. Services; Charles Dinkel, Staff Engr.; and Steve Corwin, Staff Engr., all of E. F. Drew & Co., New York.

SODIUM nitrite has been used for many years to inhibit corrosion of metals by water. In functioning as an anodic inhibitor, sodium nitrite oxidizes ferrous ions to ferric ions at iron and steel surfaces to produce a very thin adherent film of ferric oxide on anodic areas (*1, 2*). Use of an insufficient concentration of the inhibitor or use of a water having too low a pH can cause corrosion to occur only locally (*1*). If present in a sufficient concentration, sodium nitrite is an efficient corrosion inhibitor; if present in an insufficient concentration, it inhibits only the most dangerous corrosion (*3*).

The use of zinc salts in small concentrations in water for preventing corrosion of metals was discussed by Thornhill in 1945 (*4*). Evans (*3*) has classified zinc sulfate as a cathodic corrosion inhibitor. Wyllie and Cheesman (*5*) reported that the addition of 0.05 per cent sodium hexametaphosphate and 5 per cent sodium nitrite to sea water gave a high degree of protection against the corrosion of steel and that the addition of 0.01–0.02 per cent of sodium hexametaphosphate to mixtures of 3 per cent sodium nitrite and 1–2 per cent zinc acetate having a pH of 6.2–6.7 gave complete protection, but slight precipitation took place.

Nature of Tests

Experiences with sodium nitrite and a combination of sodium nitrite, zinc sulfate, and polyphosphate as corrosion inhibitors for an open, circulating cooling-water system are discussed in the paragraphs that follow. The results of tests made for evaluation of these inhibitors are reported. The tests were designed to determine the degree of protection provided by the inhibitors.

The data were obtained from a study of coupon corrosion test specimens exposed in the cooling-water system when only sodium nitrite was used as an inhibitor and when a combination of sodium nitrite, zinc sulfate, and polyphosphate was used.

The authors realize that the corrosion data obtained from the exposed corrosion test specimens are not necessarily a true measure of the rate of corrosion of the component metal parts of the system and that limitations must consequently be imposed on the interpretation of the corrosion test data. The corrosion data obtained from the exposed corrosion test specimens may nevertheless be considered indications of the type and severity of corrosion in the equipment.

The cooling tower used in these experiments is a natural-draft tower in

which water is used in air compressors and coolers. The circulation rate for cooling water is 450 gpm. The temperature of cooling water leaving the tower basin is 50°F in winter and 90°F in summer; cooling water returning to the tower has temperatures of 62° and 102°F in winter and summer, respectively. Evaporation loss, based on the rate of circulation of the cooling water, is 1.2 per cent, and windage, or drift loss, is 0.5 per cent.

Bleedoff takes place intermittently once a week. Windage or drift loss limits the cycles of concentration of makeup water to as few as $3\frac{1}{2}$, whereas as many as ten cycles could be allowed.

The water capacity of the system is 22,000 gal. The amount of makeup water required to replace losses caused by evaporation, windage, leakage, and bleedoff is 7.6 gpm.

Cooling System

The cooling system consists of carbon steel piping, brass valves, and coolers having copper tubes and carbon steel tube sheets. Prior to 1956, frequent and costly replacements of piping and fittings and extensive maintenance were required because of severe general and localized corrosion. Corrosion products, transported to relatively slow circulating locations, formed some troublesome deposits. Objectionable growths of algae were present in the cooling tower.

TABLE 1

Typical Analyses of Makeup and Treated and Untreated Cooling Waters

Item	Water Type			
	Makeup (pH 6.6)	Cooling, Untreated (pH 6.7)	Cooling, With $NaNO_2$ (pH 7.5)	Cooling, With $NaNO_2$, $ZnSO_4$, and Polyphosphate (pH 6.5)
	Concentration—*ppm*			
Total alkalinity as $CaCO_3$	29	36	45	31
Total hardness as $CaCO_3$	47	180	137	150
Ca Hardness as $CaCO_3$	26	117	90	92
Mg hardness as $CaCO_3$	21	63	47	58
Chloride as Cl	7	28	23	25
Sulfate as SO_4	30	165	173	190
Silica as SiO_2	8	27	21	26
Dissolved solids				
No inhibitors	107	351	375	377
With inhibitors			1,355	810
Total sodium nitrite and sodium nitrate as NaO_2			980	400
Sodium nitrite as NaO_2			950	295
Total phosphate as PO_4				25
Polyphosphate as PO_4				18
Zinc as Zn				15

Treatment of Cooling Water

Sodium pentachlorophenate was slug fed as a regular treatment to

introduce 40 ppm in the cooling water at the time of feeding, and a quaternary ammonium compound was periodically slug fed as a supplement to introduce 6 ppm in the cooling water at the time of feeding to rid the system of algae and prevent any future growths. From October 1956 to September 1957, a solution of sodium nitrite was gravity fed to the system in a sufficient amount to maintain the concentration of sodium nitrite as $NaNO_2$ at approximately 1,000 ppm.

From October 1957 to May 1958, solutions of sodium nitrite and a combination of zinc sulfate and polyphosphate were gravity fed to the system in sufficient amounts to maintain the concentration of sodium nitrite as $NaNO_2$ at approximately 300 ppm and the concentrations of zinc as Zn^{++} and polyphosphate as PO_4^{---} at approximately 20 ppm. More of each of the inhibitors was required at first to maintain the desired concentrations; the amount needed leveled off with time.

Because the blowdown (bleedoff) water from the cooling system contained toxic constituents, a check was made to make sure that the waste water was discharged into a waste disposal line. It was also necessary to ascertain that there were no cross connections between the cooling system and the drinking water supply in order to prevent any possibility of contaminating the drinking water with the cooling water.

Typical analyses of makeup water, untreated cooling water, cooling water treated with sodium nitrite, and cooling water treated with a combination of sodium nitrite, zinc sulfate, and polyphosphate are outlined in Table 1.

Corrosion Tests

Corrosion tests were run with $4 \times 1 \times \frac{1}{16}$-in. low carbon steel coupons which were cleaned and preweighed. Prior to initial weighing, surface dust was removed from the specimens and they were degreased in acetone and ethyl ether.

Series of corrosion tests were run with sodium nitrite as an inhibitor and with a combination of sodium nitrite, zinc sulfate, and polyphosphate as an inhibitor. Specimens were suspended in the basin of the cooling tower close to the suction line to the circulating pump. This site was chosen because it was felt that the water moved more rapidly there than at any other location in the tower basin. Coupons were removed in pairs at successive intervals during the test periods for study and evaluation. After exposure the specimens were processed and evaluated as follows:

1. Examination was made with a hand lens.

TABLE 2

Corrosion Test Data, January–April 1957

Coupon No.	Installation Date	Removal Date	Exposure Time *days*	Initial Weight *g*	Final Weight *g*	Weight Loss *g*	Corrosion Rate *in./yr × 1,000*
121	Jan. 5	Feb. 9	35	30.1331	29.7569	0.3762	5.15
119	Jan. 5	Mar. 5	60	30.1523	29.5673	0.5850	5.6
126	Jan. 5	Apr. 5	90	30.0402	28.7875	1.2527	5.3

2. The specimens were photographed.

3. The specimens were cleaned with dilute inhibited acetic acid according to the procedure outlined in ASTM D935-49 (*6*), then dried and weighed.

4. Visual and microscopic examinations were made.

5. Corrosion data were calculated.

Water Analyses

The average pH value of untreated cooling water was 6.7, and the approximate Langelier saturation pH value was 8.5 at 50°F, 7.9 at 100°F, and 7.4 at 150°F. The cooling water therefore had a corrosive tendency as it passed through the piping and equip-

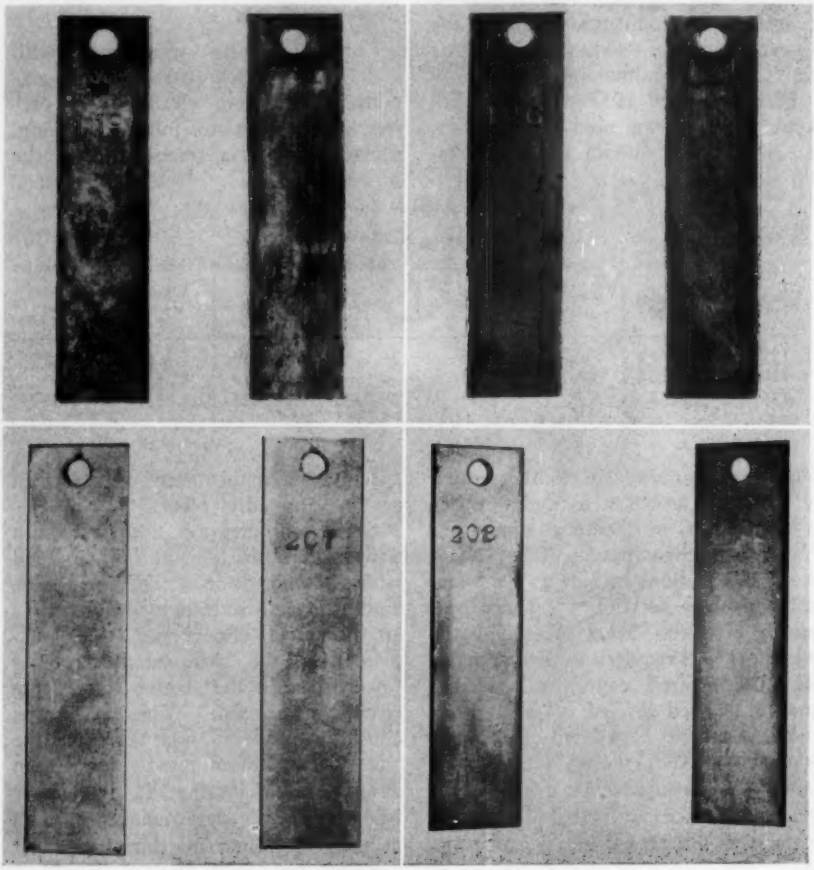


Fig. 1. Appearance of Test Coupons After Various Exposure Conditions

The coupons shown in the upper photographs were exposed to sodium nitrite alone for 60 days (left pair) and 90 days (right pair); those in the lower photographs were exposed to nitrite, zinc sulfate, and polyphosphate for 60 days (left pair) and 90 days (right pair).

ment of the system. This tendency was frequently increased by airborne acidic matter from boiler stack gases entering the cooling tower. The pH value dropped to a low of 6.2 and fluctuated in the range 6.2–7.8. This accounts for the less than expected alkalinity and more than expected sulfate in the cooling water. Because the pH value averaged approximately 7.0, a decision was made not to practice pH control.

The analyses indicate that a certain amount of conversion of nitrite to nitrate occurred. It is beyond the scope of this article to explain the mechanism of the conversion reaction. Wyllie and Cheesman (*5*) reported that the concentration of nitrite in solutions used as inhibitors does not show any measurable change and that only slight changes in the nitrite-nitrate ratio can be detected. They further reported, however, that under some circumstances nitrites may undergo changes in the presence of iron hydroxide and yield ammonia, nitrogen, or even nitrates.

The test specimens were not installed until the concentration of the inhibitors had been adjusted. Of particular interest was that before the addition of the inhibitors the cooling water had a turbid appearance and a dirty color; shortly after the addition of the inhibitors, the turbidity decreased and the color almost disappeared. An analysis of the suspended matter showed it to be predominantly iron oxides.

Slightly higher dosages of the inhibitors were needed initially to maintain the desired concentrations. This is characteristic of the type of corrosion inhibitors used, and is thought to be due to initial film formation.

Because sodium nitrite performs best as a corrosion inhibitor at pH values higher than 7 and a combination of zinc sulfate and polyphosphate performs best at pH values of less than 7, it is the authors' opinion that when the pH value of cooling water fluctuates through a relatively wide range, for example, 6.0–8.0, a proper combination of all the above inhibitors would be ideal for corrosion control.

Results of Tests

Table 2 shows data obtained during a 90-day test period when sodium nitrite only was used as a corrosion inhibitor.

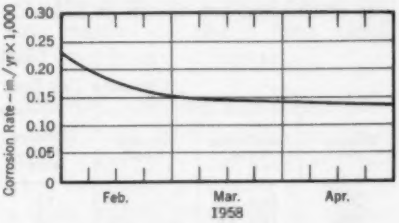


Fig. 2. Effect of Treatment With Zinc, Polyphosphate, and Nitrite

The quantities of inhibitors used were: zinc as Zn, 20 ppm; polyphosphate as PO_4, 20 ppm; nitrite as $NaNO_2$, 300 ppm. As can be seen, the addition of these inhibitors reduced the corrosion rate and held it at a nearly constant level.

The data indicate that sodium nitrite alone held the rate of corrosion to a value of near or slightly higher than 5 expressed as inches per year times 1,000. Examination of the cleaned specimens showed that the corrosion occurred as localized corrosion. Figure 1 shows photographs of specimens after 60 and 90 days' exposure.

It was the authors' opinion that if steps could be taken to halt localized corrosion, very good protection against corrosion would be obtained. One procedure considered was to increase

the concentration of the inhibitor; another was to decrease the concentration of the inhibitor and use complementary inhibitors, with the expectation that the action of the inhibitors would be synergistic. The latter course of action was taken.

The curve in Fig. 2 indicates that when a combination of sodium nitrite, zinc sulfate, and polyphosphate was used as an inhibitor, corrosion was halted and held to a negligible rate. After 90 days' exposure in the system, the specimens had the same appearance as they had before exposure. The point data from which the curve was established are shown in Table 3.

TABLE 3

Corrosion Test Data, January–March 1958

Coupon No.	Installation Date	Removal Date	Exposure Time *days*	Initial Weight *g*	Final Weight *g*	Weight Loss *g*	Corrosion Rate *in./yr × 1,000*
205	Jan. 15	Jan. 29	14	24.9195	24.9103	0.0092	0.22
206	Jan. 15	Feb. 12	28	23.8985	23.8883	0.0112	0.16
207	Jan. 15	Mar. 15	59	24.0500	24.0164	0.0336	0.19
208	Jan. 15	Apr. 15	90	23.3028	23.2700	0.0328	0.13

The relationship used in calculating the rate of corrosion is:

$$C = \frac{t_1 \times 365}{2 \times \text{days exposure}} \left(1 - \frac{w_2}{w_1}\right)$$

in which C is the corrosion rate (in inches penetrated per year); t_1 is the initial thickness of the coupon (in inches); w_1 is the initial weight of the coupon (in grams); and w_2 is the final weight of the coupon (in grams).

Conclusions

Corrosion of steel specimens by cooling water can be inhibited through the use of sodium nitrite. If, however, a sufficient concentration of sodium nitrite is not maintained, or if the pH value of the cooling water becomes too low, a high rate of localized corrosion can occur.

Zinc sulfate and polyphosphate perform synergistically with sodium nitrite as corrosion inhibitors to halt corrosion almost completely right from the start. The action of zinc sulfate and polyphosphate in helping the sodium nitrite permits the use of reduced concentrations of sodium nitrite.

Acknowledgments

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References

1. Wachter, A. Sodium Nitrite as Corrosion Inhibitor for Water. *Ind. Eng. Chem.*, **37**:749 (1945).
2. Hoar, T. P. Nitrite Inhibition of Corrosion: Some Practical Cases. *Corrosion*, **14**:63 (1958).
3. Evans, U. R. *Metallic Corrosion—Passivity and Protection.* Longmans, Green & Co. (2nd ed., 1948).
4. Thornhill, R. S. Zinc, Manganese, and Chromic Salts as Corrosion Inhibitors. *Ind. Eng. Chem.*, **37**:706 (1945).
5. Wyllie, D. & Cheesman, G. C. N. Sodium Nitrite as an Inhibitor Against the Attack of Sea Water on Steel. *J. Soc. Chem. Ind.*, **68**:165, 209 (1949).
6. ASTM Standard Method of Corrosivity Test of Industrial Water (NDHA Method)—ASTM D935. Am. Soc. Materials, Philadelphia, Pa. (1949).

Role of Corrosion Engineers in Water Supply

Paul Beermann

A paper presented on Jul. 16, 1959, at the Annual Conference, San Francisco, Calif., by Paul Beermann, Director of Operations, Water Dept., San Diego, Calif.

CORROSION affects both the public relations and the operating and maintenance expenses of water utilities, because each breakdown in the water system due to corrosion not only affects service to the customer but also requires costly repairs. Therefore, the corrosion engineer plays an important role in water supply and treatment.

The water system of a large city may consist of: reservoirs located at some distance from the city; miles of transmission mains; filtration plants; pumping plants; distribution reservoirs; distribution systems; and service lines to the customer. Each of these elements may be affected by corrosion and therefore must be protected.

Corrosion occurs on pipe exteriors for various reasons, among them adverse soil conditions and electrical currents. The insides of pipes become corroded as a result of aggressive water. The variety of metals and soils encountered in an average water system compounds the problems of corrosion.

The San Diego, Calif., water system is currently carrying out a multimillion-dollar program to replace cast-iron pipelines. The program was largely necessitated by a combination of the inadequacy of the city's unlined pipes and the effects of aggressive water and unusually corrosive soils. The cost of this program is just a portion of the estimated five to six billion dollars needed annually in the United States to repair the damage from corrosion. San Diego's program involves the replacement of approximately 600,000–700,000 ft of cast-iron pipelines that have reached the end of their usefulness long before anticipated.

Corrosion Experience

San Diego first became concerned about water pipe corrosion in 1927, when an excessive number of leaks on a 28-in. riveted steel pipeline necessitated the reconditioning of several sections of the line. Most of the leaks were caused by exterior corrosion in the line, which had been constructed in 1914 at a cost of approximately $220,000. The number of leaks continued to increase until 1939, at which time a consulting engineer was employed to review the problem and recommend possible solutions. As a result of his study, ten cathodic-protection stations were installed by the city in 1941. Following this installation, the frequency of leaks declined rapidly.

Difficulty had also been experienced with a dipped and wrapped 36-in. steel line constructed under approximately 10 ft of adobe backfill in paved streets. The first cathodic-protection station on this line was installed in 1937 and consisted of vertical anodes of scrap pipe and a rectifier. The anodes were filled

periodically with brine solution to increase their rate of electrical current transfer. It was suggested at the time that many of the city's corrosion problems were aggravated by the extensive use of water pipes for the grounding of electrical services.

At the time of the first installations of cathodic-protection stations, the city was relatively small, and the stations were placed on transmission mains in remote areas. With the rapid growth of the city, many new homes were built in these areas adjacent to the anodes of the cathodic protection stations. As a result, two problems occurred: severe corrosion of piping in the new homes and reduced protection of transmission pipelines.

In San Diego's present distribution system, which consists of approximately 1,200 mi of lines, approximately 400 breaks a year occur in the cast-iron mains. Most of these can be directly attributed to corrosion.

Tanks and Standpipes

The first cathodic protection used on steel tanks and standpipes consisted of graphite anodes connected to rectifiers. Difficulty was experienced in retaining the anodes on the support wires, which often disintegrated and fell to the bottom of the tank. The use of platinum wire did not improve the situation. At the present time, the city uses magnesium anodes suspended from the tank roofs.

Services

Early service installations consisted of lead and galvanized-iron pipe. Severe corrosion on the outside of the galvanized-iron pipe, as well as tuberculation inside, made it necessary to change to copper for all service installations. The use of copper eliminated corrosion of the service pipe but accelerated the corrosion of the adjacent cast-iron mains.

Grounding

Alternate-current grounding of electrical services is believed to be another cause of corrosion in the system. The water department has always cooperated with the electrical-power utilities and permitted such grounding. Where excessive current flows are noted, steps are taken to insulate the service on the customer side of the meter.

Gate Valves and Meters

Many millions of dollars have been invested in valves and meters throughout the system. Here again, corrosion has taken its toll, for inspection shows that many of the valves no longer close and many meter replacements are required because of corrosion within the chamber. Defective meters result in a loss of water department revenue and inconveniences to the customer.

Filtration

San Diego presently operates three filtration plants and expects to start construction on a fourth. Two of the plants use pressure filters, which have been severely affected by corrosion. Cathodic-protection stations have been installed on these filter systems but have critically affected their operation. Insufficient current does not properly protect the pipe and shells; oversupply of current has resulted in the cementing of the underdrains and sand owing to the precipitation of calcium from the water.

Other Agencies Affected

The water system is not the only city service that is affected by corrosion. The San Diego Corrosion Control Sec-

tion is often asked to assist other departments with special facilities such as sewage treatment plants, swimming pools, and fire boats. Many industrial customers also request and receive advice regarding corrosion problems.

Current Program

After many years of experience, firm policies have been developed regarding the method of corrosion control and the personnel needed to do the job. Each corrosion problem requires thorough analysis and periodic review of existing installations. And because corrosion is a continuous problem, the city maintains a small group charged specifically with this program.

The manner in which the problem was handled at the 66-mgd Alvarado Filtration Plant is an example of what should *not* be done. Approximately a year after the plant was placed in operation in 1950, severe corrosion was noted on several of the shafts in the mixing and settling basins. Cathodic protection was installed by inexperienced personnel, at a cost of about $17,000, with no improvement of conditions. Following another survey and design by experienced personnel, a second protection system was installed in 1953, and it has operated satisfactorily ever since. Frequent inspections made of all facilities have shown the metallic parts to be free from further corrosion.

Methods and Equipment

The San Diego system now has 51 cathodic-protection stations installed adjacent to transmission mains and filtration plants, and in steel tanks and standpipes. The average cost of an installation for pipeline protection has been approximately $3,000; the installations in the tanks and standpipes have averaged $500 each. Protection is obtained by the use of either galvanic anodes or external power sources. Rectifier stations are inspected semimonthly, and routine potential readings are made over the protected facilities semiannually. Insulators are used to separate dissimilar metals and to break up possible long-line currents in metallic lines, whether or not they are concrete coated. Rubber rings and other types of flexible nonmetallic couplings are used for cast-iron piping to reduce current transmission. Where alternating currents along household service piping remain greater than 1 amp, insulated couplings are installed on the customer side of the water meter. This minimizes current flow in the service piping to the main.

In areas of high soil conductivity, a polyvinyl chloride tape is wrapped around the service piping adjacent to the cast-iron main, in order to reduce corrosion of the main. Asbestos-cement distribution pipe is used where stray-current damage is high and cannot otherwise be reduced. Sections of asbestos-cement pipe or insulated couplings are installed in metallic mains at frequent intervals to reduce the transmission of stray currents.

All plans for the construction of water facilities are reviewed by a corrosion engineer who determines the possible corrosion problem and recommends corrosion control procedure for the new construction.

Corrosion control problems have been discussed with field men and design engineers to acquaint them with the factors that tend to create excessive corrosion. All water department personnel are instructed to report unusual conditions for further review by the corrosion control section. This section consists of four men. It has an annual budget of approximately $30,000, ex-

clusive of funds allocated for the installation of cathodic protection. The corrosion control section works directly under the laboratory superintendent, who is also charged with the operation of the water and sewage laboratories. It is thus possible to coordinate corrosion control in the field with the water treatment process at the filtration plants. With proper treatment of a normally aggressive water, it is possible to reduce the corrosion problem by maintaining proper calcium carbonate stability, so that the water tends neither to pick up nor to deposit calcium. By maintaining a relatively high pH (8.8–9.0), the internal corrosion previously experienced has been minimized.

Qualifications of Corrosion Engineers

The field of corrosion prevention is a relatively new one, with many factors still to be considered. Because of the great variety of corrosion problems and variations in the size and complexity of systems to be protected, no hard and fast requirements for a corrosion engineer can be set down. An organization planning a program of corrosion control should carefully consider its specific types of problems and select its personnel accordingly.

In general, the corrosion engineer in charge should have a very broad education and a high degree of training in such fields as physics, chemistry, and metallurgy. Preferably, he should have a college degree in one or more of these or related fields. He should be versatile and have the ability to recognize and deal with a diversity of problems relating to causes and prevention of corrosion, chemistry, electrical theory and practical installations, metallurgy, piping and plumbing, soils, paints, and coatings.

He should be able to get along with and talk the language of his employers, employees under his supervision, consulting experts, and laymen. Being able to speak effectively in public and to teach his assistants are valuable assets for a corrosion engineer. He should have an inquisitive and open mind, constantly on the alert to recognize and deal with new and unusual problems and to make use of improved methods. In a large organization, administrative ability is of recognized importance.

Summary

An effective corrosion control program can greatly reduce operating costs and improve the level of service to the customer. The corrosion engineer plays an important part on the water supply team, both in an advisory capacity to water utility management and in a line capacity of operation and maintenance of the cathodic-protection stations.

Types and Significance of Chlorine Residuals

Robert J. Baker

A paper presented on Apr. 23, 1959, at the Pacific Northwest Section Meeting, Vancouver, B.C., by Robert J. Baker, Tech. Consultant, Wallace & Tiernan Inc., Belleville, N.J.

ONE of the chief advantages of chlorination, when compared to most methods of disinfection, is that its effectiveness can be determined. When the presence of residual chlorine in water can be demonstrated, the effectiveness of chlorination is definitely insured, and continues as long as the residual is present. Soon after the practice of water chlorination was started about 50 years ago, it was discovered that a control was necessary to insure disinfection. The method of control devised was the addition of enough chlorine to water to bring about the residual effect. A few years later, water utility engineers became aware that residual chlorine could actually be a complex of several compounds, a fact that became generally known after the advent of free residual chlorination and the development of techniques for differentiating the various residuals.

All chlorine residuals have in common the ability to kill bacteria and enter into oxidation reactions. The amount of the residual required, the time of reaction, the optimum pH, and the practical application of each residual vary so greatly that the proper use of a residual can be made only after careful consideration of its capabilities and limitations.

Residual Chlorine Compounds

The different chlorine compounds that may be found as residual chlorine in water are: [1] hypochlorite ion (^-OCl), [2] hypochlorous acid ($HOCl$), [3] monochloramine (NH_2Cl), [4] dichloramine ($NHCl_2$), [5] nitrogen trichloride (NCl_3), [6] organic compounds containing chlorine, and [7] chlorine dioxide (ClO_2). Residuals consisting of the first two are called free available chlorine residuals. The goal of free residual chlorination is to produce and maintain this type of residual. The next four are known collectively as chloramines. Combined residual chlorination is the result of the formation of chloramines from the combination of chlorine and ammonia, when naturally present in, or when added to, water. The principal amines are mono- and dichloramine. Nitrogen trichloride is never formed in any appreciable amounts during water treatment, although its strong, penetrating odor may cause one to believe that large amounts are present. It is most likely to occur in free residual chlorination.

The organic chlorine compounds and nitrogen trichloride might be classed as "nuisance" residuals. The organic compounds are of little value because their capacity for oxidation is very low in comparison to the other forms of residual chlorine. Still, they react in the tests for residual chlorine as combined chlorine. They are exemplified by the small amount of combined chlorine residual that persists even after prolonged contact with free chlorine,

and are sometimes referred to as the "irreducible minimum" in free residual chlorination.

Chlorine dioxide, produced by combining chlorine and sodium chlorite, is another chlorine compound that may be added to water in amounts sufficient to produce a residual.

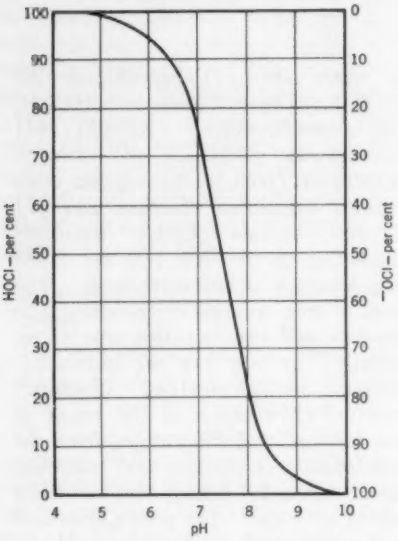

Fig. 1. Relationship Between HOCl, ⁻OCl, and pH

Because of rapid disassociation, the equilibrium between ⁻OCl and HOCl is maintained, even though the latter is continuously being used up.

pH Relationships

Of prime importance in the consideration of free chlorine residuals is that pH is a factor in the ionization of hypochlorites to hypochlorous acid. Figure 1 shows the relationship between HOCl and ⁻OCl at various pH values (*1*). It is obvious from the figure that greater proportions of hypochlorous acid are found at lower pH values. The disassociation rate to form this acid is sufficiently rapid, so that the equilibrium between hypochlorite ion and hypochlorous acid is maintained even though the latter is being continuously used up. For instance, if water containing 1 ppm of free available chlorine has introduced into it a reducing agent that consumes 50 per cent of the hypochlorous acid, the remaining residual will redistribute itself between hypochlorous acid and hypochlorite ion, according to the curve in Fig. 1. The amount of hypochlorous acid present at pH values above 10 is so slight that disinfection is seriously impaired.

If an amount of ammonia nitrogen equal to or in excess of that necessary to combine with chlorine is present or added to the water, chloramines will be formed subsequent to chlorination. If less than that amount is present, the reactions of free residual chlorination will occur, and the ammonia will be destroyed.

Mono- and dichloramines are usually considered together because there is little control over which will be formed. The amounts of each are governed primarily by the pH. Fair and colleagues (*2*) have reported on the distribution of mono- and dichloramine at various pH values. Figure 2 is a plot of these data. Note that greater proportions of dichloramine appear at lower pH values. These calculations are based on a weight ratio of 5:1 between chlorine and ammonia nitrogen. More than 3 hr is required for the reaction between chlorine and ammonia at pH 5, about 1 min at pH 8.3, and 50 min at pH 11, according to Fair's report.

Although it is generally thought that dichloramine is a stronger oxidant than monochloramine, it is nevertheless true

that monochloramine is effective as a disinfectant at pH values greater than 10. It will also release iodine from potassium iodide at pH 7; dichloramine will not. Very little has been reported on the comparable characteristics of these two compounds. Dichloramine is largely responsible for the chlorinous taste associated with chlorination.

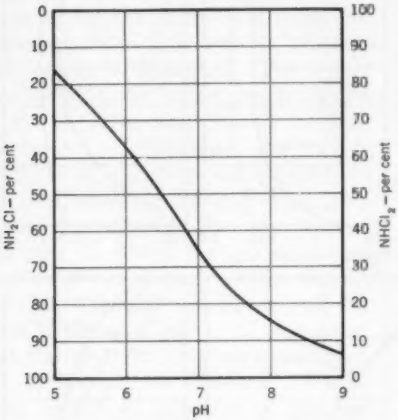

Fig. 2. Relationship Between NH_2Cl, $NHCl_2$, and pH

These relationships are based on a weight ratio of 5:1 between chlorine and ammonia nitrogen.

It has been noted that in pH adjustment following water treatment, some of the combined residual is frequently lost. It has also been noted that monochloramine is nearly always found in greater amounts than dichloramine, and in far greater amounts than indicated in Fig. 2. To check these two points, the following procedure was set up:

Tap water was treated with chlorine to remove the ammonia and leave a free available chlorine residual of 1.4 ppm at pH 7. Ammonia was added in the ratio of one part ammonia nitrogen to four parts residual chlorine. This procedure was intended to duplicate the effect for a utility practicing free residual chlorination followed by ammonia treatment to convert the residual to combined chlorine before the water is pumped to the distribution system. Immediately after the addition of ammonia, the pH was adjusted in portions of the water to values from 4 to 12, in order to study the effect of pH adjustment. These values exceed the range that would normally be encountered. At intervals, the amounts of mono- and dichloramines were determined by amperometric titration. Figure 3a shows the amount of each and the total residual after 30 min. Note that little of the total residual is lost at pH values less than 7, but that the loss at higher values is appreciable. Little dichloramine was found, but in view of the rates of formation cited by Fair and colleagues (*2*), little would be expected in 30 min. In the amperometric procedure using phenylarsene oxide, nitrogen trichloride would be expected to titrate the same as free chlorine. When a residual was found, it was assumed to be nitrogen trichloride, and Fig. 3a was drawn to show it as such. It might, however, have been free chlorine that had not yet reacted with the ammonia. At any rate, it apparently changed predominantly to monochloramine, because there was practically no loss in total residual or little gain in the dichloramine portion after 1-hr contact (see Fig. 3b).

Figures 3b, 3c, and 3d indicate the residual chlorine found in each of the pH-adjusted samples after 1, 2, and 3 hr, respectively. Although the amount of dichloramine after 3 hr is still increasing slightly, it is still far

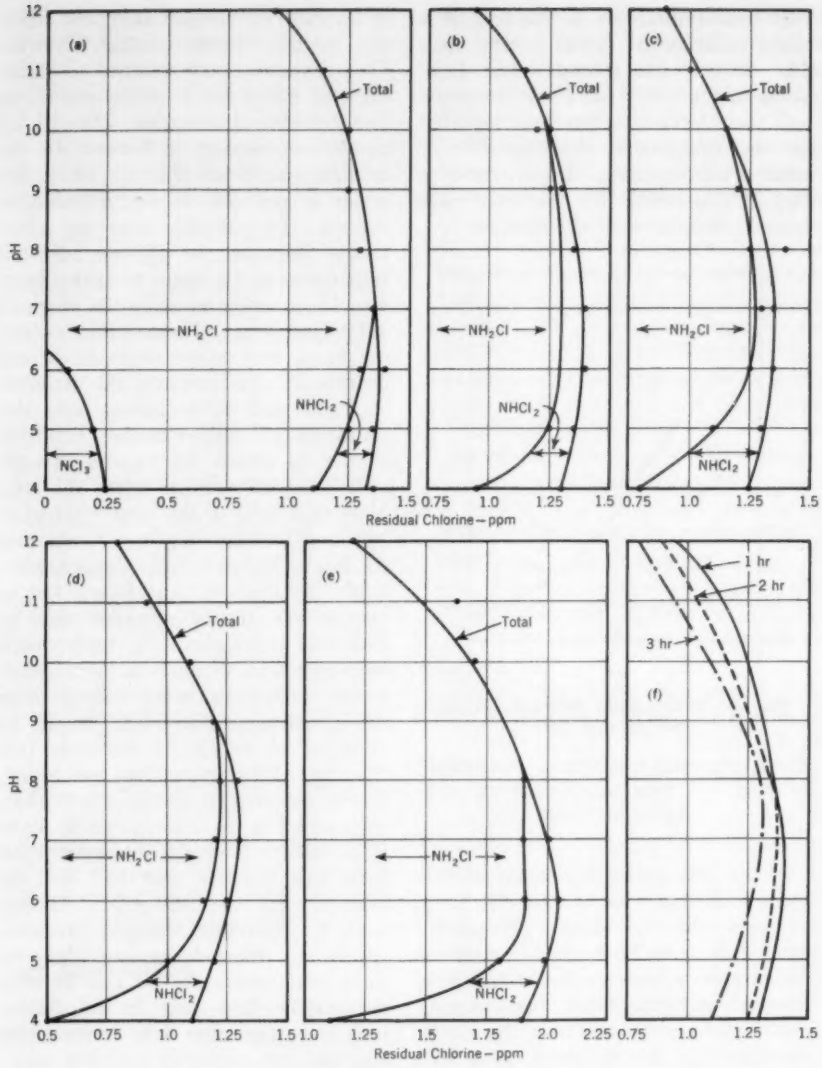

Fig. 3. Amounts of NH_2Cl, $NHCl_2$, and Total Residual Chlorine Following Time Intervals After pH Adjustments

Parts a, b, c, and d are plots of data 30 min, 1 hr, 2 hr, and 3 hr, respectively, after pH adjustment. For these determinations, the ratio of ammonia nitrogen to residual chlorine was 1:4. The data for Part e, as for Part d, were taken 3 hr after pH adjustment, but with a ratio of 9:1 between ammonia nitrogen and chlorine. In Parts a through e, the amounts of NH_2Cl are indicated on the first curve to the right of the arrow labeled NH_2Cl. Part f shows a comparison of the total residuals plotted in Parts b, c, and d.

below the amount in proportion to monochloramine as shown in Fig. 2, even at the low end of the pH scale. This confirms the observation previously stated that combined residuals are predominantly monochloramines, at least under the conditions of this test.

To check the effect of very high doses of ammonia, another test was made under the same conditions, but with a ratio of 1:9 between chlorine and ammonia nitrogen. The initial free residual was higher, but the shape of the curve in Fig. 3e and the proportion of dichloramine are nearly identical to the 3-hr data shown in Fig. 3d, indicating the little effect from excess ammonia.

Figure 3f shows the comparison of total residuals plotted in Fig. 3b, 3c, and 3d. The 30-min curve was the same as the 1-hr curve. It was noted that the greatest loss ocurred at high pH values and in the first 30 min. Very little loss occurred in the pH range 6–8.

The last of the chlorine compounds, chlorine dioxide, is unstable and must be manufactured where it is used. This is usually accomplished in water plants by mixing solutions of sodium chlorite and chlorine in a reaction tower. Chlorine, in excess of that theoretically needed, is used to depress the pH to increase the yield of chlorine dioxide. The lack of a satisfactory test for residual chlorine dioxide in the presence of residual chlorine has hindered its use in water treatment. In spite of the lack of a satisfactory test, the use of chlorine dioxide is increasing slightly because of its valuable properties: its oxidizing ability is nearly comparable to hypochlorous acid, yet it does not react with ammonia; it is a good bactericide at high pH values; and it will oxidize phenols without the formation of chlorophenols. Its chief present disadvantage is that it costs more than the other chlorine compounds.

Comparison of Residual Chlorine Compounds

The three forms of residual chlorine compounds—that is, free chlorine, combined chlorine, and chlorine dioxide—are compared in general terms in water treatment as follows:

1. *Disinfection.* Free chlorine is the most effective at most pH values, followed closely by chlorine dioxide. Combined chlorine and chlorine dioxide are both more effective than free chlorine at pH values greater than 10.

2. *Oxidation of iron.* All are satisfactory, except that free chlorine and chlorine dioxide will oxidize iron more rapidly than will combined chlorine.

3. *Oxidation of manganese.* Only free chlorine and chlorine dioxide are effective, at least within the time available in most water plant operations.

4. *Taste and odor removal.* Because tastes and odors are caused by a number of factors, the utilization of each residual compound for its specific characteristics becomes extremely important. Combinations of two or even all three may be indicated in some situations. Some taste and odor problems respond readily to free residual chlorination. The use of ammonia may be necessary in other instances to produce combined residuals, thereby reducing the oxidizing power of chlorine and preventing the production of chlorinated or chlorine-substituted compounds that would merely change the taste of water from one type to another.

Where phenols present a problem, a common practice is to employ free residual chlorination to satisfy the chlorine demand of the water and accomplish the objectives of chlorination,

followed by chlorine dioxide to remove any chlorophenols that may have been formed. Such practice reduces the requirements for the more expensive chlorine dioxide.

5. *Persistence.* Even when the chlorine demand of the water has been satisfied, other factors affect the persistence of residuals. Sunlight dissipates hypochlorous acid more rapidly than chloramines. Chloramines, on the other hand, are more easily lost by aeration than hypochlorous acid. Very little is known about the persistence of chlorine dioxide, but indications are that it reverts quickly to chlorite.

Conclusion

A knowledge of the types and characteristics of the various chlorine residuals is necessary for the most efficient use of chlorine. Apparatus for laboratory control and equipment for accurate chlorine application are available to meet the requirements of any program of chlorination selected.

Acknowledgment

The author wishes to acknowledge the assistance of George C. Clark, Sales Service Dept., Wallace & Tiernan Inc., Belleville, N.J., in the laboratory work of this investigation.

References

1. *Water Quality and Treatment.* Am. Wtr. Wks. Assn., New York (2nd ed., 1950).
2. FAIR, G. M., ET AL. The Behavior of Chlorine as a Water Disinfectant. *Jour. AWWA,* **40**:1051 (Oct. 1948).

Correction

The article by Gerhard Klein, "Concepts in Determining Potability of Water After Nuclear Attack" (April 1959 JOURNAL, Vol. 51, pp. 431–437), contained two editorial errors. On p. 435, in col. 1, Eq 1 should read

$$\frac{dx}{dt} + \lambda x = Be^{-\lambda_r t},$$

and, in line 21, the reference to Eq 3 should read "Eq 1."

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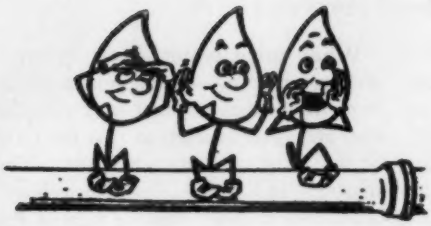

Percolation and Runoff

A man of quality is AWWA's new secretary, Raymond J. Faust—quality water, quality water service, and quality water servants being the key content of his hope chest as he took office on Sep. 1, "qualities" that he will be seeking most in his new post.

A *quality water,* Ray explains, is a water that is more than just safe. With today's knowledge and equipment, it is no great trick to make water safe, but water works men ought not to be satisfied with just keeping their customers from dying. Having the knowledge and equipment, too, to make water ambrosial to the taste, foamy to the wash, gentle to the plumbing, and practically perfect to any other purpose, they ought to be striving to bring the quality of their supplies up to the very best in all respects. And to set some goals that are higher than the USPHS safe minimums which now provide the only guideposts, AWWA has a new committee already at work developing a quality water standard.

Quality water service, of course, supplies a *quality water*—all the quality water that customers need, when and where they need it—and supplies it efficiently, at a price that covers the full cost of supplying it and that does not discriminate against any of the customers. The aspects of quality in water service are as broad as the field itself and, therefore, are perhaps a little overwhelming as a goal, but AWWA's committee on a rating scale for water utilities is now making great strides in developing a standard against which utilities can rate their present performance and establish challenging, yet attainable, goals for quality service.

And *quality water servants* are, naturally, those who are fully qualified and determined to supply *quality water* through *quality water service.* Although there are many such quality men in the field today, despite the inadequacy of present rewards, their necessity and worth must be more fully appreciated by the public before their number can be increased to that required to perform a quality job of public water supply. And on the various aspects of this chore, too, AWWA has been at work, its committees on compensation, education, and water utility advancement busy with recommending qualifications for new personnel, providing means of upgrading present personnel, setting standards of compensation that will attract and hold qualified men, and developing a public desire for and willingness to support *quality* throughout water utility operations.

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All this quality adds up to a considerable task, but it is a task in which Ray hopes all of AWWA will lend a vigorous hand so that *quality* may gain the status that *safety* now enjoys in somewhat less than the 50 years it took "safe water" to be taken for granted.

In welcoming Ray to secretarihood, we should note that he came to AWWA 8½ years ago, since which time he has been serving as executive assistant secretary, specializing in working with Association committees on such important projects as the new cast-iron pipe standards, the safety program, the education manuals, and the compensation surveys. He arrived at AWWA from the Michigan Department of Health, which he had served for 28 years, the last dozen in charge of the Section on Water Supply. He holds both civil and sanitary engineering degrees from Penn State and is a registered professional engineer in Michigan and New York. In addition to being an AWWA member since 1938 and a long-time secretary, as well as director and Fuller Awardee, of the Michigan Section, he was a cowinner of the Goodell Prize in 1950. He is a member of APHA, FSIWA, and ASCE, a diplomate of the American Academy of Sanitary Engineers and chairman of the Specialties Committee of the American Sanitary Engineering Intersociety Board. Ray and his wife, Margie (with a hard "g"), who is well known to AWWA-'ers from her convention attendance, live in Garden City, a Long Island suburb. They have a son, Jim, who is now in his second year at Hahnemann Medical School in Philadelphia.

Good luck, Ray, and remember—*quality will sell!*

What price water?—our question of long standing—seems finally to be receiving an answer that may even be loud and clear enough so that the public will have a chance to hear. The answer, of course, is "priceless." "Priceless Water" was the title of the local water utility film sponsored by AWWA and premiered at the San Francisco Conference. "Priceless Water" is the title of the community action manual developed by AWWA for use by the Junior Chambers of Commerce in promoting the film locally. "Priceless Water" is the title of a particularly well done community action guide and workbook on how to obtain good water service, prepared by Johns-Manville and also introduced at AWWA's San Francisco meeting in July. And "Priceless Water" is the label being painted on elevated tanks in some of our communities to call respectful attention to their contents. Meanwhile, to establish the basis of the pricelessness, the Water & Sewage Works Manufacturers Assn. has issued a folder that gives "Some Facts About the Industry That Has Been Called Our Worst Public Works Problem" in an attempt to eliminate the conflicting figures and terminology which have been confusing the public.

Altogether these efforts constitute only a small start on the long and difficult task of convincing the public that water really is priceless, but there is hope. At its San Francisco meeting AWWA took further steps through its Advancement Program to promote community relations activities. At San Francisco WSWMA embarked on a new public relations effort keyed to selling the public on "Better Living With Better Water Service" that is to

(*Continued on page 48 P&R*)

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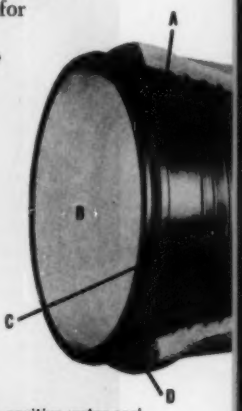

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(*Continued from page 46 P&R*)

work hand-in-hand with AWWA's program, channeling its major efforts through the mass media via such instruments as a television film, a syndicated cartoon feature, "better water service" releases, and a speakers bureau. Meanwhile such individual efforts as that by Johns-Manville and, earlier, by the Cast Iron Pipe Research Assn. will fortify the basic program so that one day, perhaps, priceless water need no longer be inadequate water, nor, indeed, profitless water. Need we suggest: "A Better Living With Better Water Service!"

The price of waterlessness, meanwhile, was being assayed in two small communities whose water systems went completely dry last month as a result of equipment failures. First, at Lineville, Iowa, population 700, failure of the pump in the 1,300-ft deep well on the city's 5-year-old water system apparently also drained the 33,000-gal elevated tank and left the mains empty. Householders who had kept their backyard pumps as ornamental were happy to find them still functional as well, while others, including business firms, had to haul water from wherever they

Flanking David B. Lee (third from left), director of the Florida Board of Health's Bureau of Sanitary Engineering, are the recipients of the board's annual awards for the best operated water plants in the state: Joe M. Logan (left), Pinellas County Water System; Al Norris, Winter Park Water Plant; J. T. Hoffman, Naples Water Dept; Paul Samuels, Hialeah Water Plant, Miami; and J. N. Hogerich, Orr Water Plant, Miami.

(*Continued on page 50 P&R*)

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(Continued from page 48 P&R)

could find it during the 2½ days required to get a new pump and put the system back in service. Meanwhile stoves and refrigerators did extra duty in making the emergency supplies safe and palatable.

Then at Roy, N.M., population 750, failure of the pumps on the town's two wells, located 7 mi north, was traced to overloading caused by the distintegration of the mains in the 14-year-old system. Everyone turned to in the job of hauling water from the wells into town, and a tank truck owned by a highway contractor provided some relief, but the town's two cafes and its hotel had to shut down and the solution being sought was no better than another tank truck. The main, which was said to be made with "low-grade wartime pipe with a life expectancy of 8 years," could not be repaired or replaced despite the availability of funds, as state law prevented the transferring of funds from surplus into water works accounts.

As with most public waterlessnesses, these two, too, were primarily pump- and pipelessnesses, with perhaps more than a modicum of engineeringlessness as well. What price populationlessness?

H. F. Cronin has retired as chief engineer of London's Metropolitan Water Board. His successor is W. M. Lloyd Roberts, for many years deputy chief engineer. Mr. Cronin was elected an Honorary Member of AWWA in 1956.

What was good for General Motors is now good for Esther Williams if marketing psychologists and motivation researchers are correct in noting that the private swimming pool has displaced the automobile as the "status symbol" of our society, for Esther, aside from having prettier and more useful fins than any GM car ever, is president of the International Swimming Pool Corp., producers of Esther Williams Swimming Pools in sizes and prices ranging all the way from the Chevrolets to the Cadillacs of the backyard. And with size and "extras" such important considerations in statusian symbology, a changeover at this time certainly seems entirely logical. After all, 1960 cars threaten to start a real trend toward smaller models with less power that get more miles per gallon and may even cost a "little" less. From the viewpoint of properly denoting class and prestige, such a trend can be considered no better than communistic.

No, henceforth a man's position must be judged by his pool. No pool, no position, we say—and no excuses either. After all, 200,000 families will have private pools by the end of this year, their prices and terms will be comparable with those of 1959 automobiles, and certainly the water they use will cost less per gallon than gasoline. Space is no problem either; if there's no room in the backyard, then in the basement or, perhaps, the "family room"; one of the most luxurious we've heard of is a 7½x16x5½-ft deep pool built into the trailer home of one of Hollywood's bachelors. When it comes right down to judging, such significant details as length and width and depth and type of construction, and such appointments as lights and diving boards and ladders will all be taken into consideration, and certainly quality of water will have to be a primary concern, but for real status, of course, there'll be no pool like an old pool.

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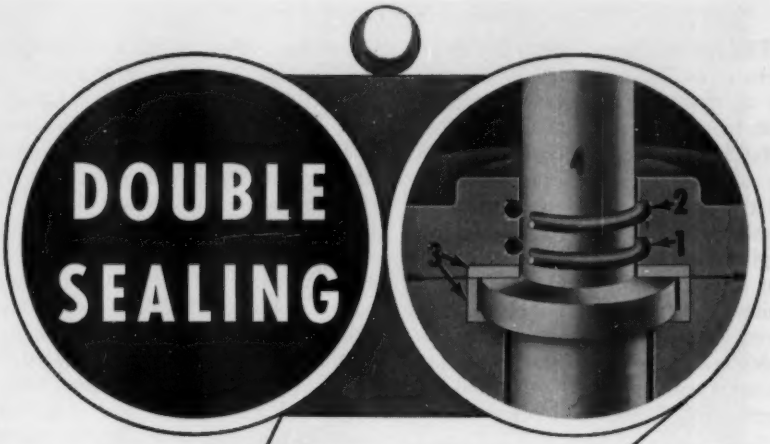

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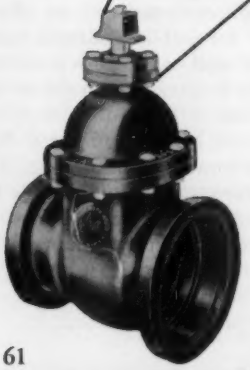

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(*Continued from page 50 P&R*)

The meter reader goeth not so far, perhaps, as first suggested by the variety of electronic devices advanced to push him completely out of the picture (May P&R, p. 38). At any rate, Badger Meter Mfg. Co. appears to have cut the distance to no more than half a mile with its new "Read-O-Matic Register," which can be located up to that distance away from the meter to which it is attached. Made up of an enclosed electromagnetic generator, which is attached to the meter in much the same way as conventional dial registers, and a sealed, solenoid-driven

register counter, which is connected to the generator by doorbell-class wiring, the register system operates solely on energy produced by the meter. Through "careful selection of metallic and nonmetallic materials to provide high corrosion resistance, good structural strength and wear resistance, satisfactory electrical properties, and low cost," Badger's Research & Development Div. not only has given the meter reader hope of continued existence—not to mention dogbitelessness —but has won a nationwide competition for the best use of materials in product design, sponsored by the magazine, *Materials in Design Engineering*.

The half-mile readings, of course, contemplate the possibility of central reading stations, which will reduce the footwork of meter readers, but most applications of the new system will probably involve locating the registers where they will be accessible to the readers without disturbing customers or their property. In Water District No. 1 of Johnson County, Kan., meanwhile, the male population is already investigating the possibility of taking the new register along to the office (see cut).

Perhaps, in fact, the meter reader bounceth back!

For those who sticketh around, meanwhile, there is good news indeed in the announcement from the University of Georgia of a new dog gun that shoots hypodermic-like tranquilizer pellets. Developed to help in Atlanta's antirabies drive against wild and stray dogs, the gun—equipped with an effective silencer for public relations purposes—might well be the answer to the meter reader's pressing problem of canine canines. Loaded with just enough of mutt Miltown to get a dog gone for the duration of a reading, the gun might even speed up readings to a point where humanics would have at least a chance against electronics. And if it didn't, it would at least also give the meter reader a means for preventing ulcers from worrying about it.

Vail H. Moore has opened an office as consulting engineer at 101 W. Ottawa Rd., Paxton, Ill. He was formerly with Hazen & Sawyer.

(*Continued on page 54 P&R*)

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(*Continued from page 52 P&R*)

Hersey Mfg. Co. is celebrating its centennial this year. Founded in 1859 by Walter E. Hawes and Charles H. Hersey, its chief product then was the rotary pump. Hawes & Hersey became Hersey Bros. in 1872, when it began making sugar refining and other machinery. It entered the meter business in 1885, first as Hersey Meter Co. and later (1890) as Hersey Mfg. Co. The growth of the company is exemplified by the contrast (see photos) between the machine shop in South Boston where it was first housed and the 150,000-sq ft building at Dedham, Mass., which it has occupied since 1957.

The 12th World Health Assembly, attended by delegations from 82 of the nations participating in the World Health Organization, met at Geneva in May. The assembly stressed the importance of safe and adequate community water supplies to health and to social and economic development. The assembly requested WHO to cooperate with member countries in water supply projects and to continue to study possible means of financing them. A special fund to receive voluntary contributions for WHO activities in this field was established. A coordinated global program for community water supply is envisaged under the leadership of WHO.

Hydrants, heat, and humanity figured in three riots in New York City last July in which one man was shot, one stabbed, one hit by a garbage can, while one woman had her head split open with a board, another was burned critically, and four received less serious burns from a Molotov cocktail thrown from an apartment building roof. All three riots occurred during a 2-day

(*Continued on page 56 P&R*)

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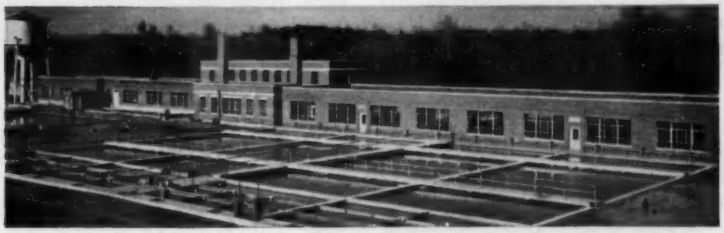

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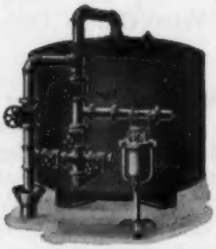

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(Continued from page 54 P&R)

heat wave at the beginning of the month and involved city sufferers who tried to cool off in the spray of nearby hydrants. Two of those hurt were firemen who had turned off hydrants that were illegally on; the shooting and skull-cracking followed the spraying of bypassers from a hydrant that was legally on; and the rest were bystanders injured when overheated hydrant bathers were thwarted in their efforts to cool off. "New York City," New York City says, "Is a Summer Festival"—with water sports and fireworks yet!

General Waterworks Corp. has announced the acquisition of a number of water utilities, the largest being New Rochelle (N.Y.) Water Co. The others are: Preston Utilities Corp., Joliet, Ill.; Shore Hills Water Co., Lake Hopatcong, N.J.; Western Hill Utility Co., in the Denver, Colo., area; South Gate Water Co., adjacent to Sarasota, Fla.; and North Miami Shores Water Co., in Dade County, Fla.

ASME's new president will be Walker L. Cisler, president of Detroit Edison Co. He will be installed in December, along with vice-presidents Charles H. Coogan, William C. Heath, Donald E. Marlowe, and Henry N. Muller Jr.

The scientific program of the Fifth International Water Supply Congress, to be held in Berlin in 1961, will comprise the following seven subjects: water disinfection, surface and ground water pollution, metering and meters, statistical analysis of water utility operating data, applications of automation, problems of local and regional water supply systems, and large-diameter pipe design and installation. Like the Brussels Congress of 1958, the Berlin meeting will be sponsored by the International Water Supply Assn.

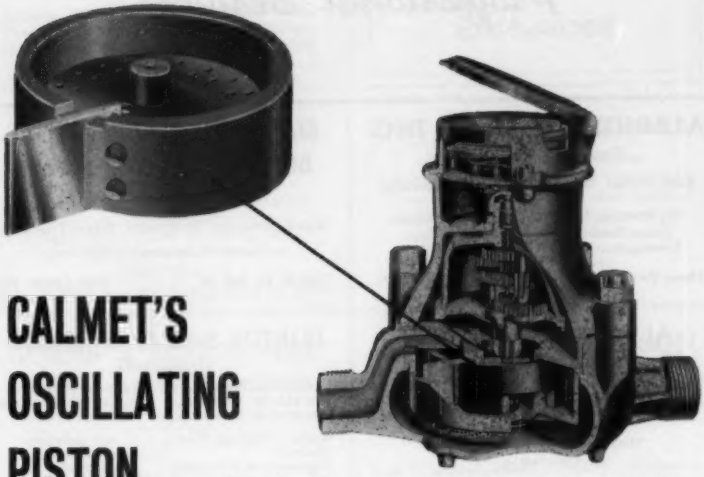
Good Government Award of the Allentown, Pa., Junior Chamber of Commerce was presented this year to Harry J. Krum, recently retired manager of the city's water department, for his accomplishments over 41 years of service, and particularly for his work in the establishment of the Allentown Water Authority, a city laboratory, and a 30-mgd filter plant completed in 1953, and for his good start on metering the system. What with this and the Pennsylvania Section's 1955 Fuller Award to show for his professional feats, the only thing lacking for Harry's complete happiness is proper recognition for his not-so-professional feats on the golf links.

As early as 1935 Harry made golfing headlines for a rather unusual birdie —one with feathers—as his tee shot killed a swallow on the wing. But the publicity following that shot was only a whisper compared with the excitement when another of his drives killed a 13-in. trout in a creek that crossed one of the local club's fairways. And if some of the comment tended toward "a swallow we can swallow, but a trout . . . ," this, too, was an attested achievement. Somehow, neither the unusual birdie nor the unusually fishy has yet won him the Good Golfer Award he claims to merit, if not for shooting a good game, certainly for shooting good game.

Congratulations, Harry, for being dubbed "Man of the Year." And congratulations, man, for being harried dub of the year.

(Continued on page 112 P&R)

the Inside story:



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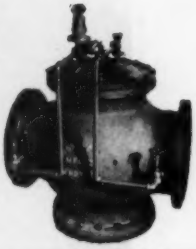

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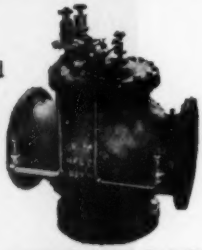
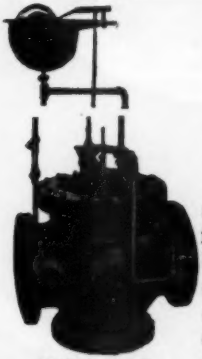


COMBINATION VALVE

Combination automatic control both directions through the valve.



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Maintains levels in tank, reservoir or basin

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2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

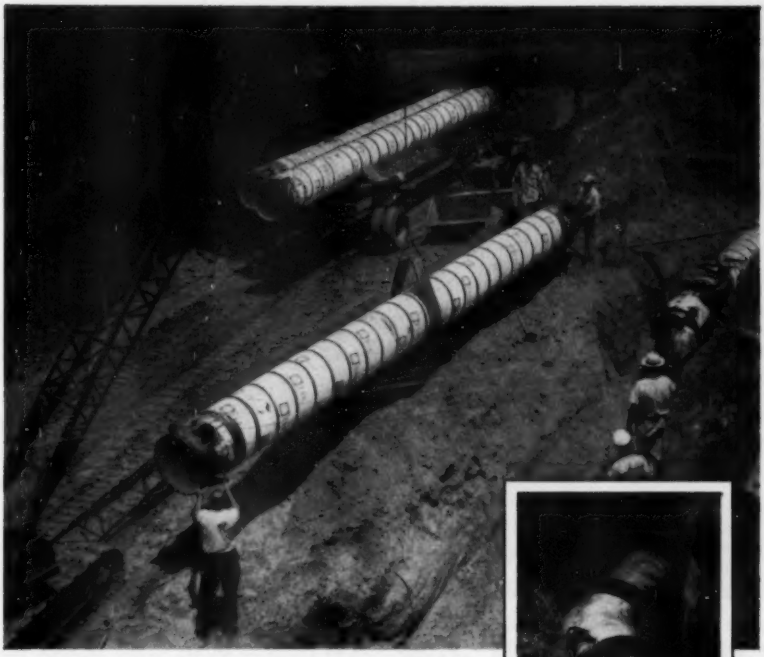
POLLUTION CONTROL

Nerve Gas in Public Water. J. EPSTEIN. Public Health Repts., **71**:955 ('56). In event of chem. warfare contamn. of water with nerve gases Sarin and Tabun must be considered, as very small quants. of these agents are required to produce toxic symptoms from ingestion. Behavior of Sarin in water is discussed. Hydrolysis occurs producing nontoxic acids, reaction being more readily catalyzed in basic solns. But acids produced in reaction lower alky. and cause Sarin stability. Reaction of Tabun in water is different for acid and basic pH values. In basic solns. Tabun tends to stabilize, but in acid solns. products of hydrolysis are 1 acid and 1 base; therefore pH remains constant and reaction continues. Tabun is detectable in water by its distinctive taste and odor, and its alteration of chlorine demand of water. Sarin is not so readily detectable, but estimations of fluoride ion concns. and alterations in pH of water are helpful in its detection. Response of 3 species of fish has been used to aid in detection of Sarin and Tabun in water. Once detected both these nerve gases can be rapidly destroyed by simple decontamn. procedures.—*WPA*

Jurisdiction Over Pollution—The Federal View on Water Pollution. G. E. MCCALLUM. Chem. Processing, **21**:32 ('58). Primary responsibility for water poln. control rests with states, with federal govt. in supporting role. Federal Water Pollution Control Act of 1956 (P.L. 660) is reviewed to point out activities and authority of USPHS regarding water poln. Tech. assistance activities are being directed more and more to regional and interstate problems rather than to problems of individual states. Basic-data program has been initiated to establish national network of sampling stations to provide base lines for measuring progress in water quality improvements and for detecting deterioration of resources. USPHS is working with universities and other groups in developing techniques, based on fundamental economic principles, for detg. what poln. is costing local areas or regions and expenditures which can be economically justified for its control. In interstate water poln. cases, state and interstate action is encouraged. USPHS places emphasis on cooperative program of voluntary compliance to obviate necessity for federal enforcement action. In developing and carrying out federal water poln. control program, Surgeon General has advice and assistance of Water Pollution Control Advisory Board and National Technical Task Committee on Industrial Wastes. Major emphasis in program is being placed on research in effort to further scientific knowledge concerning behavior and effects of today's complex wastes and to develop adequate methods of control.—*PHEA*

Legal Aspects of Stream Pollution. CARL E. GEUTHER. Sew. & Ind. Wastes, **30**:1050 ('58). Control of water qual. through abatement of poln. will contribute much to meeting water deficiencies. Water laws are being changed and must continue to change to keep pace with changing economy. Curbing poln. has been given much attention, as evidenced by fact that from 1953 to 1956 some 269 water poln. bills were considered by state legislatures. Several states have adopted comparative-injury or public-interest doctrine, which has served to deny injunctions if offender would suffer much greater injury than plaintiff. State statutes, interstate compacts, and federal legislation which have been superimposed on common-law rights have set certain limits on permissible poln.; simplified amt. of proof necessary for prosecution of law suits; and paved way for more frequent action by state or commission officials in nature of a collective suit for nuisance abatement.—*PHEA*

(Continued on page 70 P&R)



Atlanta, Georgia: This 8200′ extension of the existing water supply main system was laid by Arthur Pew Construction Co. of Atlanta. The line is Dresser-Coupled throughout.

Two man-minutes per bolt make every Dresser Coupling a permanent, bottle-tight joint.

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with Dresser-Coupled Pipelines

It's easy to install a Dresser-Coupled steel waterline. There's no need for expensive, specialized equipment and labor; and installation is so rapid that the line is often fully laid immediately behind the trencher. Ordinary labor can make permanent, bottle-tight joints in a matter of two man-minutes per bolt. The joints will last the life of the line.

And Dresser® Couplings protect the line, too. These non-rigid couplings absorb vibration, stresses of expansion and contraction, shocks and pressures of shifting or settling earth. They allow up to 4° of pipe deflection at every joint, and joints are made with plain end pipe. Why not figure your next water line with Dresser Couplings? You can figure your costs *accurately* . . . and consistently *lower!*

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(*Continued from page 68 P&R*)

Importance of Treatment of Waste Waters to Preserve the Purity of the Ruhr and the Effect of Reservoirs on the Ruhr. E. H. PRUSS. Bul. Centre Belge et Document. Eaux (Fr.), **26**:238 ('54). Constitution of the water of Ruhr at various stretches along its course, until it joins the Rhine at Duisburg, is described. An account is given of efforts made to reduce poln. of river flowing through industrial areas, and of treatment plants installed in towns to prevent entry of pollutants into river. Special reference is made to treatment of waste waters from distilleries, paper factories, cellulose works, iron and steel works, metal works, atomic-energy establishments, coal mines, and coke works. Waste waters from a town are often treated with sewage. A description is given of 3 reservoirs constructed on Ruhr, lakes Hengstey, Harkort, and Baldeney, and of phys., chem., and bact. properties of water passing through them. Results are given in tables, and illustrations and diagrams are included of some of treatment plants described.—*WPA*

BACTERIOLOGY

Choice of a Selective Medium for the Routine Insolation of Members of the *Salmonella* Group. R. W. S. HARVEY. Mon. Bul. Minist. Hlth. Lab. Serv., **15**:118 ('56). Comparison was made of capacity of 3 selective media to isolate *Salmonella* organisms from feces and sewage in routine anals. Media studied were MacConkey's brilliant green medium, deoxycholate citrate agar, and Tabet's modification of Wilson and Blair's medium. Exptl. procedure, and constituents of media are described. MacConkey's medium was found to be most satisfactory, as it is comparatively simple to prepare, it has high selectivity over wide range of selective agents, and variability in its properties is rare. Results are shown in tables and are independent of material examd. whether it be feces or sewage. Results are also independent of type of *Salmonella* present—the typhoid bacillus, *Salmonella typhi*, being the only exception, as it was not isolated during course of expts. Organism does, however, grow well on MacConkey's medium.—*WPA*

A Substitute for Bile Salts in Culture Media. J. E. JAMESON & N. W. EMBERLEY. Gen. Microbiol. (London), **15**:198 ('56). Expts. have shown that anionic detergent Teepol is satisfactory substitute for bile salts in media for organisms of *coli*-typhoid group. Medium contg. 0.1% Teepol and indicator of sulphonphthalein group gave more accurate results than did MacConkey's medium. Bile salts, as marketed, are expensive and variable in their bact. properties but Teepol is cheap and reliable.—*WPA*

Comparative Studies on the Presence of Coliform Bacteria and Bacteriophages of Some Pathogenic Intestinal Bacteria in River Water. S. ZIEMINSKA. Rocznicki Panstwowego Zakladu Hig. (Pol.), **9**:225 ('58). Comparative studies were carried out on presence of coliform bacteria and bacteriophages of *S. typhosa* Vi, *Shigella flexneri*, and *S. schottmuelleri* in water from Vistula R.—*CA*

Identification of *Escherichiae* in Water; Eijkman's Test and the Production of Indole at 44°C! IMViC Tests. R. BUTTIAUX; J. SAMAILLE; & Y. PIERENS. Ann. Inst. Pasteur Lille (Fr.), **8**:137 ('56). Of 323 strains of *Esch. coli*, 92.6% fermented lactose with production of gas in medium of Mackenzie and produced indole after 48 hr at 44°C. None of 116 strains of *Esch. intermedia*, *Freundii*, *Klebsiella*, and *Cloaca* had this property. This technique had specificity and sensitivity comparable to more complicated techniques. For methyl red and acetylmethyl-carbinol tests, synthetic medium of Fouad is recommended. Incubation takes place at 30°C for 48 hr in former reaction, and for 24 hr in latter. Urease test in *Escherichia* should be performed in Christensen's medium at 30°C and not at 37°C. Under these conditions all strains of *Klebsiella* and *Cloaca* from feces and urine studied hydrolyzed urea, in contrast to strains isolated from water. Hypothesis that urea-producing *Klebsiella* strains from water are dangerous contamns. can thus be tested more easily. Although only 16% of *Esch. intermedia* and *Freundii* strains from feces and urine hydrolyzed urea at 37°C, nearly 90% did so at 30°.—*PHEA*

Lignasan as Bactericide and Algaecide. R. E. BURROWS & B. D. COMBS. Progressive Fish Culturist, **20**:143 ('58). Coincidental with expts. employing Lignasan (ethyl mercury phosphate, 6.25%) for control of bact. gill disease of fishes, it was observed that

(*Continued on page 72 P&R*)

The scene is South Broad Street, with City Hall in the background.

Laying steel pipe in PHILADELPHIA: 1907

When the city photographer snapped this pipe-laying crew on Broad Street in 1907, the city was installing nearly 27 miles of steel pipe, in 48-in. and 36-in. diameters. Most of that pipe is still in service—after more than 50 years on the job!

1959—Installing 60-in. tar-enameled Bethlehem steel pipe in Northeast Philadelphia. Contractor: Armour Excavating, Inc.

Matter of fact, in Philadelphia they have for many years specified steel pipe for most mains over 30 in. ID.

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(Continued from page 70 P&R)

this compd. was also effective algaecide. Tests indicated that concn. of 1.0 ppm was adequate for control of green algae. Lignasan administered at concn. of 1.0 ppm for 1-hr exposure at biweekly intervals was particularly effective for control of some branched and unbranched filamentous green algae. 3 methods are described by which pond may be treated with 1.0 ppm Lignasan rather than the previously recommended 2.0 ppm for control of bact. gill disease.—*PHEA*

DISTRIBUTION SYSTEMS

Designing an Adequate Water Supply System for Rural Schools. P. Bouthillier & W. A. Milligan. Munic. Util., **95**: 8:17, 44 ('57). Authors discuss factors affecting design of water supply systems for rural schools in Canada. Studies were made in 3 schools in Alberta and results are shown in graphs and tables. It is recommended that vol. of water used per pupil should be estimated as 15 gpd, and that min. fixture requirements should be increased.—*WPA*

Water Intakes in the Niagara River and Lake Ontario. R. H. Murray. J. San. Eng. Div., Proc. ASCE, **84**:1607 ('58). Recently completed ('56) water supply intake in Niagara R. for town of Tonawanda (present pop. 95,000) is described. Intake is located 2,000 ft upstream of a sandbar which splits Niagara R. into 2 channels and is opposite borderline between Buffalo and Tonawanda. Buffalo is contiguous on south and upstream from Tonawanda. Submerged intake structure consists of triangle with apex upstream and inlet port downstream. Intake crib is connected by a horseshoe-shaped, concrete-lined tunnel about 5,800 ft long to shaft or riser well located on shore. Construction cost for intake system was $1,233,100. Soon-to-be-completed water supply intake in Lake Ontario for city of Oswego is described. Oswego is on south shore of Lake Ontario about 35 mi. north of Syracuse, N.Y. Intake crib is located 6,200 ft offshore in about 60 ft of water. Submerged steel crib is octagonal in shape, compartmentalized to allow weighting with concrete when in final position. Crib is connected by tunnel with min. dimension of 8 ft and capacity of 120 mgd to a shaft or riser well on shore. It is probable that tunnel will not have to be lined. A 72-in. diameter pipe connects the riser well to the

(Continued on page 74 P&R)

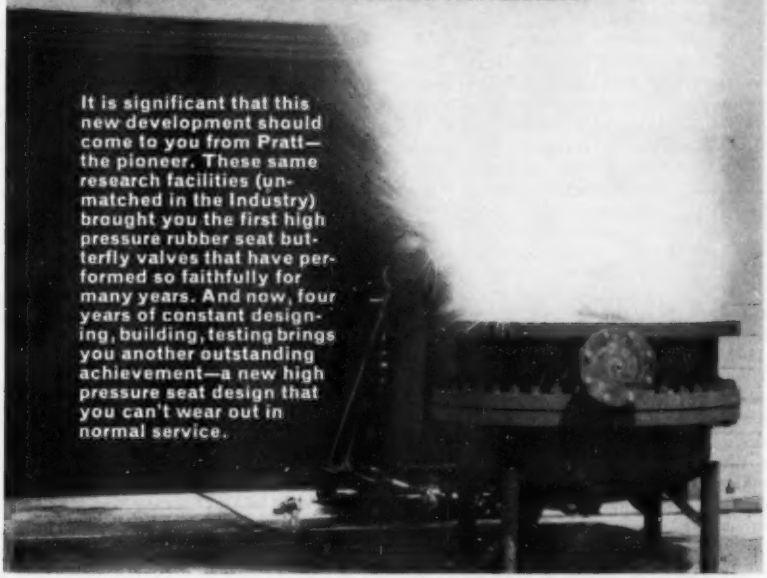
New high pressure valve by Pratt proves as RELIABLE as OLD FAITHFUL

We tried to blow this new seat out. But it couldn't be done. We tried to make it leak under high pressure. But it couldn't be done. In fact, we tried every kind of torture test imaginable—and only proved one thing. Beyond question, this new A.W.W.A. 125-16, high pressure rubber seat butterfly valve is as reliable as "Old Faithful."

The multiple segment mechanical retention not only holds the seat with completely reliable firmness, it provides easy adjustment and even seat replacement without removing the valve from the line, or the disc from the valve. Less seating torque is required with resultant savings in operator sizing.

and all this at considerable cost reduction!

It is significant that this new development should come to you from Pratt—the pioneer. These same research facilities (unmatched in the Industry) brought you the first high pressure rubber seat butterfly valves that have performed so faithfully for many years. And now, four years of constant designing, building, testing brings you another outstanding achievement—a new high pressure seat design that you can't wear out in normal service.



48" valve being tested for seat retention by snapping disc open with 150 # differential pressure across closed disc.

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(Continued from page 72 P&R)

pumping station 75 ft away. Construction bid of intake is $1,753,415 and the contract bid for construction of the pumping station is $1,055,151.—*PHEA*

Problems in the Computation of Rain Overflow Outlets (Ger.). W. Losse. Gas- u. Wasserfach, **99**:84 ('58). Computation values for measurement of rainwater overflows were tested on basis of several studies and data concerning rainwater distribution were summarized in order to interpret rainwater overflow so that sewage canals would not be needlessly overloaded. Overloading, slope of land and position of canals can result in values of 6–10 liters per sec. per hectare. This value must be detd. separately for each locality. For practical considerations, rainwater over flows still contain a lot of mud. Author presents practical calcn. example from Middle Rhine area.—*PHEA*

Water for Our Far North Outposts. J. L. Staunton & S. Rosanoff. Eng. News-Record, **160**:13:39 ('58). Method of providing water supplies for small defense outposts in permanently frozen areas is described. Most of water sources are lakes which can freeze to depth of 6 ft and, therefore, water is taken from below max. depth of ice, heated to prevent freezing during its flow to heated pump house and transported through heated pipeline to enclosed storage tanks; electricity is used to provide necessary heat. Design calls for intermittent operation of water system, and full drainage between operations. Method of intake and operation of system are described.—*WPA*

Water Intakes in the Detroit River. E. A. Hardin. J. San. Eng. Div., Proc. ASCE, **84**:1592 ('58). New water supply system will serve the suburban communities of the southeastern part of Wayne Cty., Mich. Important features of new system are water intake in Detroit R. and a 4-mi, 12-ft diameter raw-water tunnel extending inland to pumping station and treatment plant. This system and other intakes of Detroit R. are described.—*PHEA*

Aluminum Alloys for Handling High-Purity Water. W. W. Binger & C. M. Marstiller. Corrosion, **13**:59 ('57). Aluminum alloys have been used for more than 20 yr for storage and distribution systems handling distilled water. Recently, it became possible to investigate experience with some 30 distilled-water systems which had been in use for various periods of time up to 24 yr. Many of these systems had been made entirely of tinned copper or brass and others were made up of combination of material including aluminum. Results indicate that aluminum alloy storage tanks, tubing, fittings and valves are highly satisfactory for handling distilled water and do not cause significant contamn. of water being handled. Increased use of ion-exchange method for treating water has required equip. fabricated from materials in which such water could be handled with min. of pickup and discoloration. As many processes require large quants. of water of very low tot. solids content, it was natural to consider aluminum alloys for fabrication of storage tanks and piping for handling demineralized water.—*PHEA*

Use and Significance of Pipe Net Models and Modern Computation Machines for Planning and Operation of Large Water Supply Systems (Ger.). J. W. Korte & H. Bodarwe. Gas- u. Wasserfach, **99**:177 ('58). In developmental studies in large and strongly netted water supply systems, there always arise new questions on pipe and system design. Survey is given on suitable, mathematically exact designs of ring systems. From experience, work can be so time consuming that calcg. machines can be used to better advantage. Development of 2 principal types of these, analog computer and digital or cipher counter, was outlined, and their function, as far as usefulness for water supply networks is concerned, was clarified. All calcg. machine work assumes that calculation problem is balanced by characteristics of machine. An addnl. assumption is measure of roughness of operation of pipes. System measurement and exact calcn. are equiv. ingredients of system anal. Both kinds of calcg. machine can satisfy uniqueness of a water works operation.—*PHEA*

Investigation of an Obsolescent System of Drinking Water Supply. P. Gevaudan & R. Gay. Rev. Hyg. et Med. Sociale (Paris), **5**:2:190 ('57). Marseilles is supplied with river water conveyed to town by canal 80 km long. Certain suburbs are supplied with water which is untreated except

(Continued on page 76 P&R)

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(Continued from page 74 P&R)

for chlorination. Center of city is supplied with water which is filtered and sterilized. Domestic supply is via storage cisterns in roofs of houses. Formerly, cisterns may have provided a reserve in case of interruption of flow of canal, but, except in some suburbs where there is no reservoir, this is no longer necessary. Present investigation was undertaken to find out whether these tanks really serve any useful purpose. It is concluded that in chlorinated raw water they are useful as they act as contact tanks. Water at the exit shows a reduced chlorine and bact. content. In filtered and sterilized supply contact tanks are incorporated in system and so storage cisterns merely provide a possible source of contamn. and waste. Of tot. of tanks examd. 15% were site of significant pollution of water that was previously bact. satisfactory. Authors discuss whether modification to obtain better protection or suppression altogether of these storage cisterns would be preferable. Water co. favors latter but authors mention that it would be wrong to underestimate popular feeling in favor of storage cistern as reserve.—*BH*

Flow of Suspensions of Noncohesive Spherical Particles in Pipes. H. E. Rose & H. E. Barnacle. Eng. (Lond.), **203**:898 ('57). Pressure drop along a pipe conveying suspensions of noncohesive particles in air has been investigated and a formula developed from results. Pressure may, in an inclined pipe, be divided into a static pressure term, calculable from height between pressure points and density of suspension, and a frictional term which depends on phys. properties of fluid and of suspended solid but not on angle of inclination. Frictional pressure drop may be calcd. by addn. of pressure drop for fluid component alone, computed from normal formulas, and a term computed from phys. characteristics of suspended solid and of fluid by means of formulas of authors. —*WPA*

(Continued on page 80 P&R)

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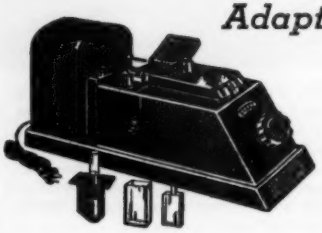

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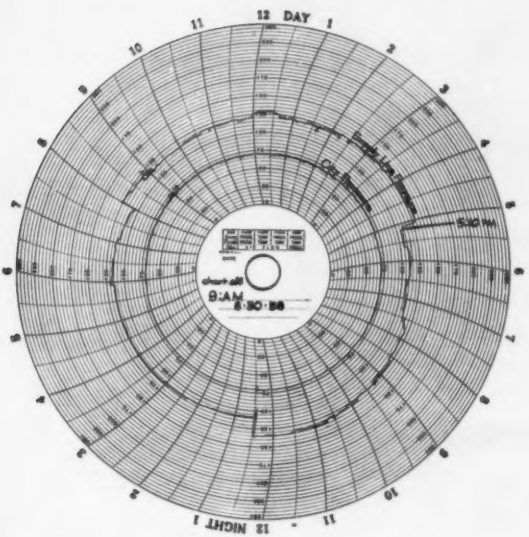

Actual pressure recording meter chart shows how City pressure remains constant despite variations in supply line pressures over a 24-hour period. **EXAMPLE:**

Time	Supply Pressure	Flow Rate	City Pressure
5:00 p.m.	135 psig	8.9 MGD	70 psig
5:10 p.m.	105 psig	15.0 MGD	70 psig

Commissioner Hugh Brewer says: "We are pleased with the continuous, dependable service of these Rotovalves."

"They are the best control valves I ever saw," testifies Water Superintendent John Luce.

Ft. Smith Relies On Allis-Chalmers ROTOVALVES *For*
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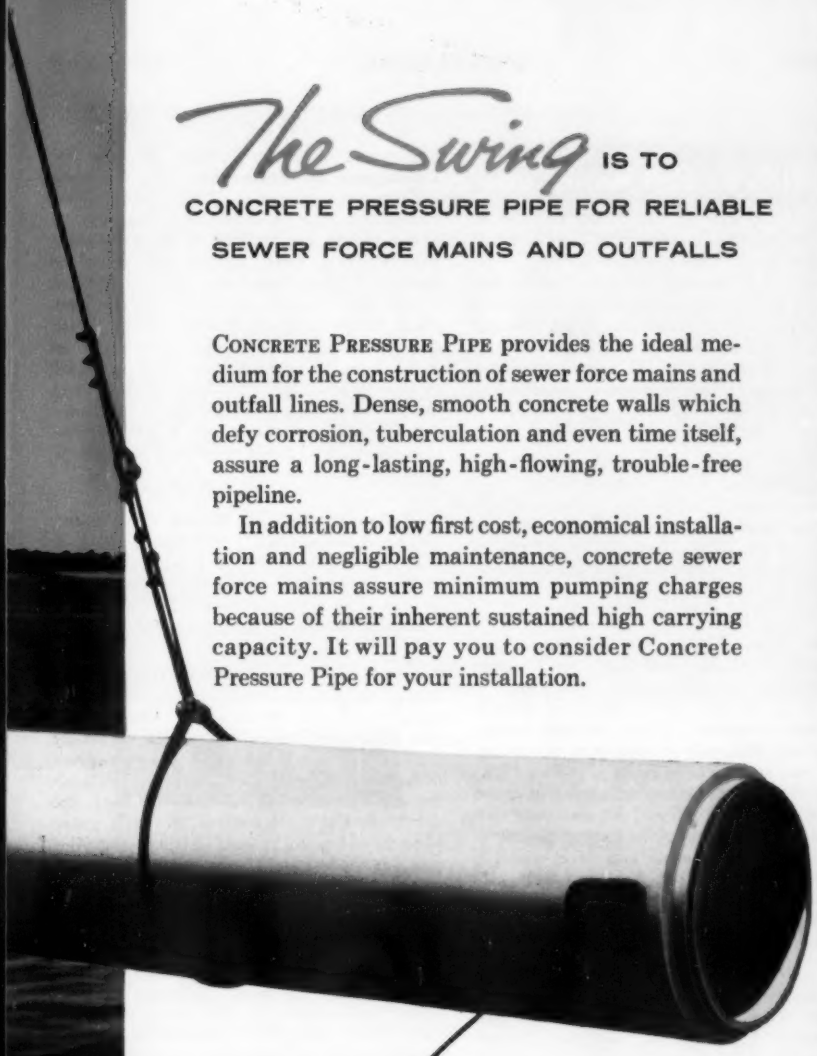

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(Continued from page 76 P&R)

BOILERS AND FEEDWATER

How Gulf Purifies Its Boiler Water. F. L. RESEN. Oil Gas J., **55**:6:106 ('57). At Port Arthur, Tex., refinery of Gulf Oil Co., feed water for high-pressure boilers is demineralized by passage through a sulfonated styrene resin and highly basic quaternary amine polystyrene resin in series. Water supply is mixture of salt and fresh water in ratio of 1,600 parts to 181 parts by volume. After demineralization water is deaerated to prevent corrosion.—*WPA*

Boundary Layer Processes in Heated Boiling Tubes. H. E. HOEMIG. Mitt. Ver. Grosskesselbesitzer., **47**:113 ('57). Author describes phenomenon of "hideout" of salts in boiling tubes, criticizing accepted theory and developing and formulating quantitatively new theory.—*WPA*

Boiler Water Treatment: A formula for Control of Sludge and Scale in Internal (Carbonate) Treatment. J. A. GRAY. J. Inst. Fuel, **30**:577 ('57). Study of internal carbonate treatment of low-pressure boilers has shown that only 2 conditions are necessary for successful control of sludge and scale—that tot. carbonate alkalinity in boiler should be between 200 and 300 ppm, and that magnesium hardness of feedwater should be maintained above certain min. level which is related only to calcium hardness and silica concn. of feedwater. Formula for calculating this is given. This method is independent of type of boiler and of water supply.—*WPA*

Adaptation of High-Pressure Boilers to a Water Supply Containing Increased Salt Content. V. N. NOEV. Voprosy Proekt. Ekspluatatsii Voclopodgotovitel. Ustanovok na Teplovykh Elektrostantsiyakh (USSR), 30 ('55). For high-pressure boilers that will be supplied with chemically treated water contg. increased salt content it is recommended to use removable sections in 2nd and 3rd stages of evapn. as in medium-pressure boilers. Possible schemes for such removable sections are discussed as well as variants in development of method of introducing water-steam mixt. into cyclones and sepn. arrangements in clean sections. In high-pressure boilers silica must be removed.—*CA*

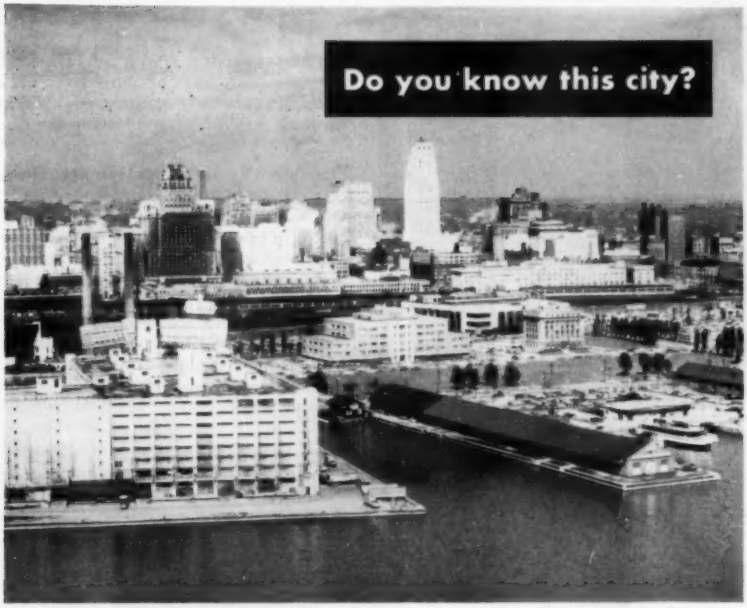
Utilization of Heat Content of Slag for Production of Feedwater. R. DOLEZAL. Strojirenstvi (Prague), **7**:93 ('57). Heat content of slag of combustion furnaces in power plants was utilized by direct contact with 80°–90°C water. Temp. was raised by approx. 3°, then water was partly evapd. at 0.5-0.7 atm. Condensate was used as feedwater in power cycle after desalting. Production of condensate, expressed as % of steam capacity of boiler, was approx. equal to heat loss in slag, expressed as % of heat introduced by coal. When steam was condensed with combustion air, temp. increase of approx. 25°C could be gained for each % heat loss in slag.—*CA*

Cyclohexylamine in Water Treatment. W. K. ASHCROFT & P. N. HERON. Eng. & Boiler House Rev., **74**:51 ('59). Review is given of properties of cyclohexylamine and its use to prevent corrosion of Fe by steam condensate contg. O and CO_2.—*CA*

Methods of Determination of Water Hardness. M. COVELLO & M. L. BIOSIO. Boll. Soc. Nat. Napoli, **66**:18 ('57). Comparative crit. examn. of various methods, especially with reference to influence of various degrees of hardness of water, is presented. Following are concluded: [1] for low hardness, due chiefly to Ca^{++}, old method of Clark (soap ppt.) is satisfactory; but Titriplex and Eldridge methods should be preferred when Mg is present too; [2] for potable water with hardness due only to Ca^{++} Titriplex and Boutron-Boudet methods are satisfactory, but same as above is true if Mg is present; [3] for high hardness, Eldridge and Titriplex methods should be used. Influence of NaCl addns. on hardness was also investigated: by all methods, hardness decreased but then increased again, by increasing Cl^- concn. This fact is ascribed to behavior of activity coeff. of strong electrolytes.—*CA*

Effect of Surface-Active Agents on the Formation of Boiler Scale. G. H. IRELAND. Corrosion Prevent. & Control, **5**:10:57 ('58). Formation of scale is discussed, and mechanism is suggested for formation of common calcite and anhydrite scales frequently found on heating and cooling surfaces of industrial plants. Types of treatment are compared and advantages of use of specially developed

(Continued on page 82 P&R)



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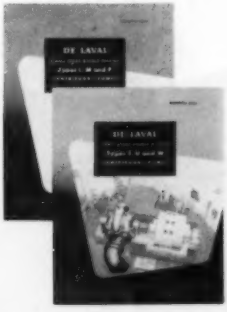

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(Continued from page 80 P&R)

org. surface-active agents are shown. Related compds., such as antifoams, O scavengers, and neutralizing amines are discussed, and their applications indicated.—*CA*

Tests on the Bruckdorf Boiler Designed for Salt-Containing (Brown) Coal. H. Loemke & H. Gerhardt. Energietechnik, **8**:539 ('58). This boiler consists of an initial section of Lamotte type followed by a short fire-tube boiler. Originally, horizontal superheater coils were placed between Lamotte and fire-tube sections, but these accumulated such heavy ash deposits that they were changed to horizontal coils after fire-tube section. Brown coal burned has net heating value of 2400–2500 kcal/kg and ash content of around 7–9%. This coal is burned in trough-type stoker and is screened to remove fines and pieces over 40 mm. The Cl^- content is around 1%. Considerable trouble is encountered with deposits throughout boiler, and intensive cleaning schedule must be used. Boiler is designed for an operating pressure of 15 atm. abs. and superheat temp. of 250°C. These values are not reached, especially during latter part of long runs, owing to low draft available from stack. Actual capacity of boiler is 7–8 m. tons/hr. This boiler is used to supply steam for briquet plant. Suggested changes are to rearrange piping in Lamotte section to act as a mixing and fly ash removal screen. It is suggested that this might be kept free from deposits by washing with blowdown water from boiler. Narrow passages and constrictions must be avoided in boilers burning salt-contg. brown coal, or passages will be clogged with ash.—*CA*

Results of Experiments on Softening of Boiler Feedwater in a Simple Device. A. Lutze-Birk. Przemyst Fermentacyjny, **1**: 168 ('57). River water, with CO_2 hardness 12–6 and noncarbonate hardness 4 German deg., was treated with CaO 0.7, Na_3PO_4 1, and $Na_2CO_3 \cdot 10H_2O$ 10 kg/7 ton H_2O and softened by 2-hr heating to 80°–106°C in a fire-tube boiler to 2.5 German deg. The sludge was removed by filtration.—*CA*

Treatment and Control of Boiler Feedwater: New Interpretations. E. C. Potter. J. Inst. Fuel, **32**:218 ('59). Appraisal of selected features of feedwater treatment for high-pressure steam boilers is made in light

(Continued on page 86 P&R)

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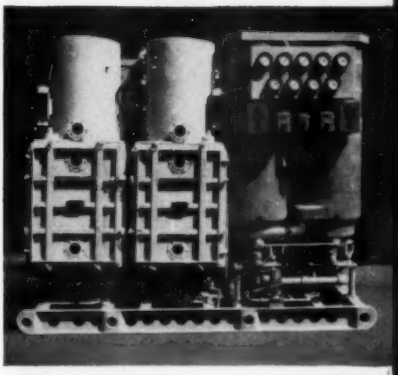

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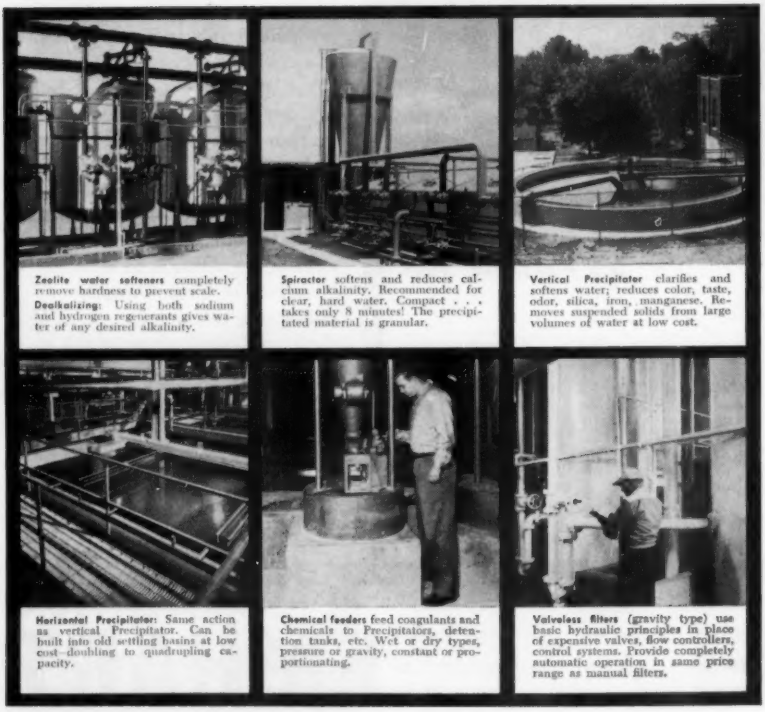

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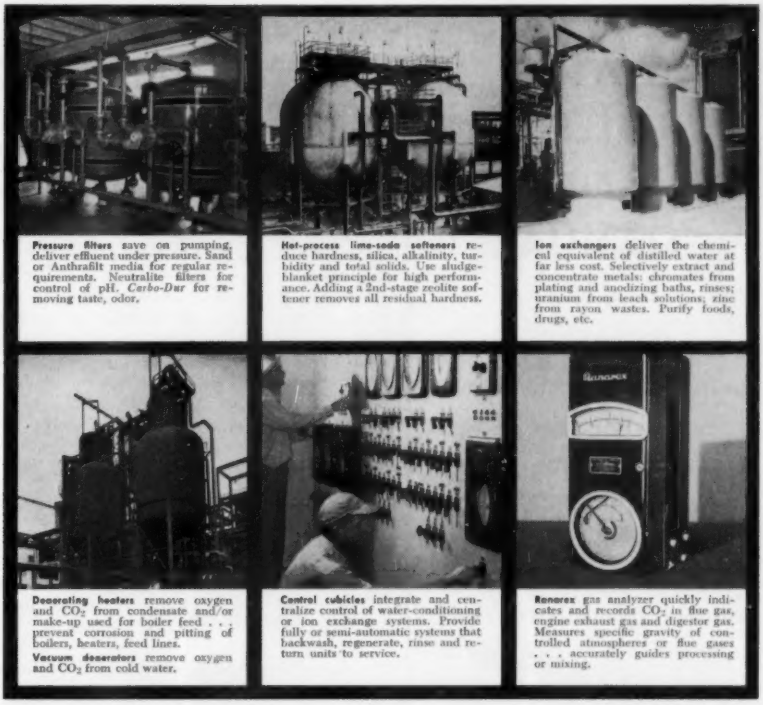

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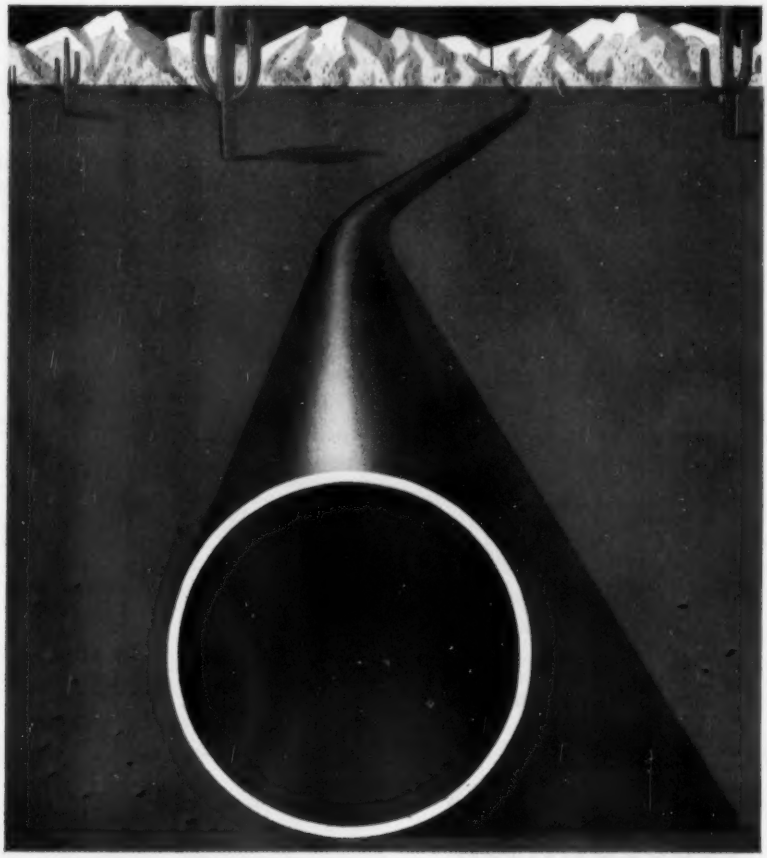
(*Continued from page 82 P&R*)

of recent information and ideas. Statistical methods are used to exam. need for deoxygenation of feedwater and to assess any advantage in addn. of alkali. Both of these processes are beneficial, but greater efficiency of deoxygenation would not necessarily reduce corrosion. Alky. arising from dissoln. of massive Fe itself is no replacement for addn. of alkali. Use of pH as measure of feedwater quality presents difficulties, although in certain circumstances it will monitor feedwater treatment. A more useful parameter may be pOH, which is much less dependent on temp. than is pH. Practice of H measurement not only fails to give desired information, but also lacks a convincing theoretical basis. In considering whether boiler design should be more flexible to remove need for even better quality feedwater, attention is drawn to safe upper limit of boiler tube thickness.—*CA*

The Use of Phosphates in Water Treatment. K. REIF. Gas- u. Wasserfach (Ger.), **99**:1354 ('58). Use of phosphates in water treatment is reviewed, including use of threshold treatments, phosphates in boiler operation, and in warm-water handling. Example is given of damage to wooden water-cooling tower when thinned hurdles were loaded with carbonate to point where internal structure collapsed. To avoid recurrence, water was decarbonated and stabilized with polymeric phosphates.—*CA*

Content of Sodium Silicate and of Free Silicic Acid in Superheated Steam From Straight Tube Boilers at 110 Atmospheres. YU. M. KOSTRIKIN, ET AL. Teploenergetika, **4**:4:37 ('57). Exptl. setup for detg. silicic acid content of superheated steam is described with use of schematic diagram. High-pressure wet steam at 450°C and 140 atm. passes cooler in which it loses some of its moisture, and regulating valve to separator where residual moisture and entrained impurities are removed. After this purification it enters mixer where Na_2SiO_3 or free H_2SiO_3, prepd. by ion exchange of its Na salt, is injected in varying amts. Thence it passes to tubular heater 20 mm in diam. jacketed with high-pressure steam where it attains temp. required for conditions of expt. On leaving heater it passes condenser and regulating

(*Continued on page 88 P&R*)



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(Continued from page 86 P&R)

valve that maintains pressure at 110 atm. to stainless-steel measuring tank from which samples are taken periodically. Detn. of SiO_3 ion is made with photo-colorimeter through blue Mo complex without extn. with BuOH. Solns. of H_2SiO_3 used for addn. are unstable above concn. of 425 mg/l, but even at 850 mg/l pptn. is negligible in 2-day period. Results of tests of Na_2SiO_3 feed plotted as mg SiO/kg steam v. temp. of steam leaving heater show that in 360°–430°C range, regardless of variation of Na_2SiO_3 feed from 0.3 to 49.5 mg/kg steam, ionic concn. remains const. at 0.03–0.04 mg/kg. With feed less then above amt. concn. in steam leaving heater falls accordingly. Its independence of velocity of steam which varied from 8 to 20 m/sec indicates true soly. and that entrainment is not involved. Below 360°C curve rises abruptly, which is explained by hypothesis that at these temps. Na_2SiO_3-NaOH fusions form entrained droplets. In expts. with H_2SiO_3 feed, efforts to correlate temp. of steam leaving heater with its SiO_3^{--} content were unsuccessful, but it was shown that it was straight-line function of silicic acid dosage, i.e., the curve has terminal coordinates of 0–0 and 12–26 mg/kg of silicate in steam and feed, resp.—*CA*

Performance of Sulfide-Forming Burnishing Compounds in Tubes of Water Gages. V. N. Gulyaev & K. I. Yatsenko. Elek. Stantsii. **28**:6:77 ('57). Two compds. are described, one contg. NaCNS (**I**) 2, $Na_2S_2O_3$ (**II**) 6, Na_2SO_4 55, KCl 45 g, other one being made up of **I** 3.5, **II** 10, $BaCl_2$ 31, $CaCl_2$ 47, and NaCl 22 g. These are applied at 130°–140°C for 15–20 min. in feedwater and produce coating of tubes of water gages with sulfide which will protect gages at later operation with high-pressure steam up to 660°C. If such compds. are not applied, none of tubes will last longer than 1,762 hr.—*CA*

Preventation of Cupric Scale Formation by Addition of Sodium Hexametaphosphate. N. N. Man'kina; M. D. Loginov; & T. A. Sashina. Teploenergetika, **3**:10:33 ('56). Treatment of steam boiler with

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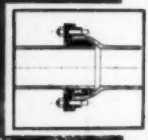

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$(NaPO_3)_6$ at 35 atm. pressure and 240°C decreases formation of cupric scale on shielding pipes from 5–7 mg/sq cm/mo to 0.3 mg/sq cm.—*CA*

Differential Regulator of Pressure of Feedwater. Yu. M. Nogovitsyn. Energetik, **5**:10:11 ('57). Regulator is described which operates with steam, which also gives partial deaeration of H_2O which is to be fed into boilers.—*CA*

The Salt Content of Steam From Drum-Type Boilers. E. Schumann. Brennstoff-Waerme-Kraft, **9**:137 ('57). Review of mechanism carryover of salts and SiO_2 in steam, including soly. of salts and SiO_2 in steam and effect of foaming and priming. Danger of foaming increases with increasing boiler-water concn., but salt content and cond. of steam leaving boiler can be maintained at substantialy const. and low level, regardless of boiler-water salt concn. by means of suitable construction and inserts, steam washing, etc. Phosphate in boiler water reduces SiO_2 content of steam. **Antifoam Materials.** E. A. Ulrich. *Ibid.* 141. Use of antifoam additives to boiler water is usually effective in preventing heavy salt deposition on turbine blades. When they are not effective, examn. of boiler drum will usually indicate mech. carryover of water droplets. Several examples are given.—*CA*

Water Treatment for Industrial Requirements. W. B. Gurney. Louisiana State Univ., Eng. Expt. Sta., Bul. No. 62, 113 ('58). Review of water quality requirements for high-pressure boilers. Case histories: a cut-back in lime dose for economy resulted in low Ca hardness with high Mg hardness; increasing lime lowered Mg hardness with Ca hardness high, tot. hardness remaining same. Very little sludge deposited in boiler tubes. Leakage of Ca and Mg through zeolite following lime treatment was in same proportion as in influent. Degradation of demineralizing resins was stopped by increas-

(Continued on page 92 P&R)

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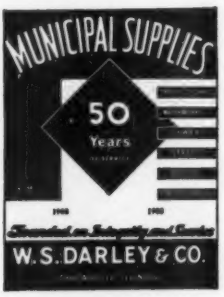

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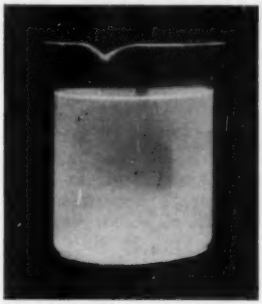
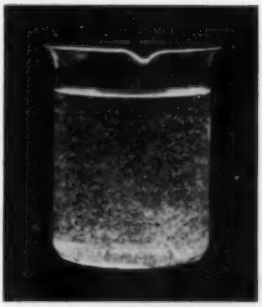
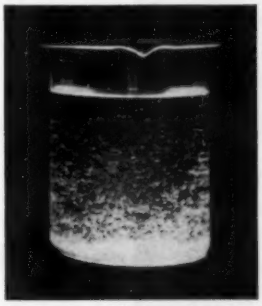


Untreated control sample of a turbid raw water.



Same water with 50 ppm alum added, photographed 7 seconds after ceasing agitation.



Same water with 20 ppm alum and 1 ppm Nalcolyte 110 added. Photo 7 seconds after stopping agitation shows rapid settling rate of larger, denser floc.

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ing regenerant chemicals and backwash rate. Intermittent feeding of waste caustic from demineralizers about once or twice monthly to raise circulating water from pH 6.5 to 10.0 laid protective film sufficiently to prevent costly condenser tube failures. **The Works Water Treatment System.** J. J. TRACHTENBERG. *Ibid.*, 116. **Design Decisions on New Water Treatment Installation.** T. E. POUNDS.—*CA*

Boiler Water Treatment—Formula for the Control of Sludge and Scale in Internal Carbonate Treatment: Experiments in a Laboratory Boiler. E. F. THURSTON & L. FURNIVAL. J. Inst. Fuel, **30**:585 ('57). As it has been shown that problems of sludge and scale formation in carbonate-treated boilers can be controlled by adjusting magnesium cont. of the feedwater in relation to its calcium and silica concns., expts. were carried out with exptl. boiler to det. effect of magnesium in feedwaters on amt. of adherent deposit and scale formation. Results showed that little scale formation occurred when magnesium was present in amts. sufficient to produce mobile sludges and that therefore addition of magnesium to water deficient in it is capable not only of imparting free-flowing properties to sludges but also of greatly reducing scale formation. These results were confirmed in full-scale plants.—*WPA*

The Quantitative Determination of Soluble Humic Acids and Their Removal From Boiler Feedwaters. W. FUCHS & E. KOHLER. Mitt. Ver. Grosskesselbesitzer. (Ger.), **47**:107 ('57). In order to study quantitative determination of humic acids in water and their removal from boiler feedwater, authors developed method, which is described, for obtaining and isolating humic acids from brown coal. Tests were made of detn. of humic acids by oxidation with potassium permanganate, using both American and the German methods of detg. permanganate

(Continued on page 94 P&R)

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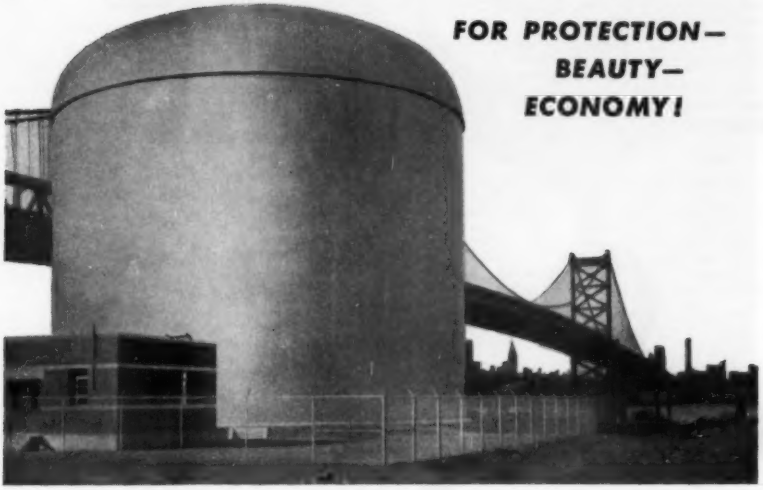

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(Continued from page 92 P&R)

demand, and with ceric sulfate. Oxygen demand on titration with permanganate was higher in acid than in alkaline soln.; German and American methods gave almost identical results; oxygen demand by the ceric sulfate method was considerably less than by permanganate method; chloride content of the soln. hardly affected results. Detailed description is then given of quant. detn. by light absorption in ultraviolet range. Studies were made of range of application of Lambert-Beer law and of occurrence of Tyndall scattering. Measurements showed that humic acids could be detd. in very small concns. even in far-ultraviolet range and that influence of Tyndall scattering was small. Comparison with a no. of organic colloids showed that with humic acid solutions kept in sterile conditions absorption remained same for several months whereas with other colloids absorption increased with increasing age. No difference was found in detn. by this method of humic acids from different sources. Sources of interference and precautions necessary are described and details are given of use of method for detg. humic acid in feedwater. Methods for removing humic acid from feedwater were studied. Addition of coagulants did not give complete removal. Design and operation are then described of filter in which water contg. humic acid is passed through deposited cake of filter aid. Using mixture of 2 trade celite products and aluminium oxide, humic acid was removed practically quantitatively from feedwater contg. 10 mg/l. —*WPA*

The Ammonia–Carbon Dioxide Water Equilibrium in Boiler Feedwater Conditioning. C. D. Weir. J. Appl. Chem., Lond., 7:505 ('57). Two methods for conditioning of boiler feedwater by ammonia, are described. One method is suitable for application to drum-type boilers, and other is intended specificially for forced-flow boilers. Equations, tables, and graphs showing equilibrium between ammonia and carbon dioxide in aqueous solns. at stated temps. and pH values, are given. Term equivalent pH is defined, and put forward as basis for design of high-temp. feedwater-conditioning equipment. Equilibria between gaseous and dissolved carbon dioxide and ammonia are discussed, and applied, for example, to estimation of behavior of power plant deaerator.—*WPA*

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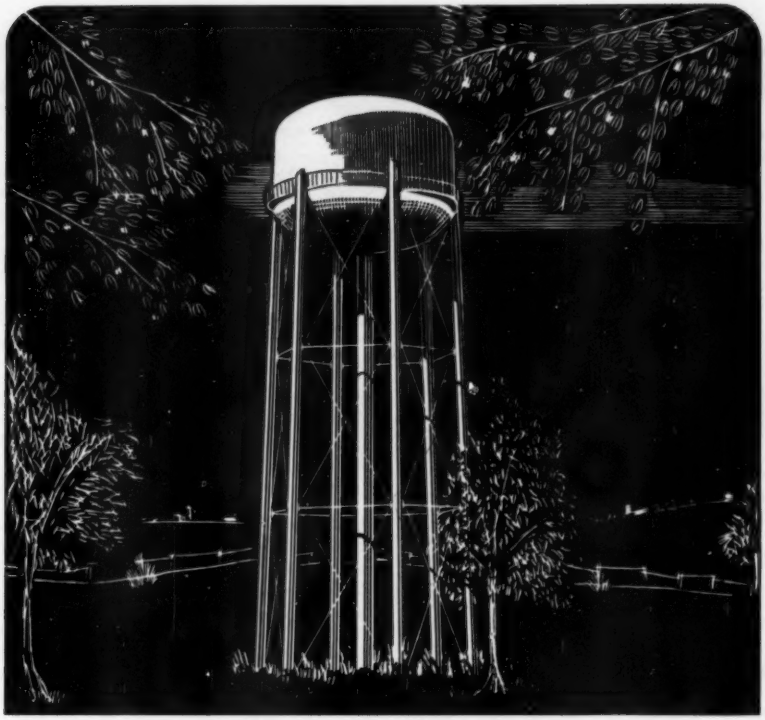

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(*Continued from page 94 P&R*)

The Preparation of Water for Boiler Feed Purposes. J. H. RAMAGE. Gas J., **293**:218 ('58). Various types of impurities occurring in water, including dissolved gases, substances causing hardness, chlorides, silica, and various sodium salts, are discussed with reference to their effect in boiler plants. Methods of treating water before feeding to boilers include: filtration to remove suspended matter and, with addn. of coagulants, to eliminate colour; softening, by lime-soda process, with or without treatment with sodium phosphate, by Zentner process, or by exchange methods; removal of silica; and mechanical or chemical deaeration. Alternatively, softening can be carried out inside boiler by treatment with alkali or phosphate; chemicals must be added to prevent adherence of sludge to boiler. In addn. to softening, water for boiler feed purposes sometimes needs conditioning, which may include addn. of alkali, deaeration, addn. of tannin-phosphate to inhibit deposition of scale, and addn. of volatile amines to prevent corrosion. Entrainment of boiler water in steam, resulting in corrosion of steam condensate system, can be prevented mechanically or by addition of antifoaming agents to water.—*WPA*

Water Supply in High-Pressure Boiler Operating in Power Plants of Moscow Regional Power System Administration. L. A. CHERNOVA & A. V. ASEEVA. Inform. Materialy Moskov. Raion. Upravlenie Energ. Khoz., **8**:3 ('55). Referat. Zhur., Khim. Abstr. No. 12759 ('57). Difficulties in connection with corrosion of equipment, with low quality of condensate recovered after operation, and increased carryover of SiO_2 by steam are recorded. It is recommended to increase requirement as to purity of steam (silica content $\leqq 0.01$ mg/kg, salt content $\leqq 0.1$ mg/kg), to carry out a desilicification of addnl. water, and to purify condensate.—*CA*

Use of Sodium Hexametaphosphate for the Stabilization of the Circulation Feedwater in Boilers. L. N. KRASNOVA. Inform. Materialy Moskov. Raion. Upravlenie Energ. Khoz., **8**:56 ('55). Referat. Zhur. Khim. Abstr. No. 12755 ('57). It is necessary to keep excess of PO_4^{---} in the circulating water of approx. 1 mg/l (the carbonate hardness of the water was 2.5–6.1 mg-equiv./l) to avoid scale formation.—*CA*

FOREIGN WATER SUPPLIES

The Problem of Drinking Water in Belgium. L. POLLET. Aqua, **3**:6 ('57). Author summarizes authorities which distribute water in Belgium; sources from which drinking water is obtained; sources of water which are available for future use; and future water requirements of country. Map of Belgium, showing principal water-bearing strata, is given. Since ground water supplies are already fully used, surface waters must be used for future requirements. Advantages of constructing a dam on Ourthe R. or taking water directly from Meuse R. are compared.—*WPA*

The Supply of Potable Water at the Town of Toulouse (Fr.). S. BLANCAL. Tech. Sanit. Munic., **52**:9 ('57). Since 1932, when pop. was 200,000, daily water supply to Toulouse has consisted of 20,000 cu m from Portet and Clairfont and 30,000 cu m from filters at Pech-David. In 1944, due to various losses, Portet-Clairfont only supplied 10,000 cu m per day to treatment plant at Bourrassol; output of filters at Pech-David was, however, increased by 20% following installation of rapid cleaning equip. using compressed air and water, of coagulation plant, using both potassium permanganate and iron sulfate, on banks of Garonne R. and of automatic equip. to control rate of filtration; this gave a daily supply of 46,000 cu m for a pop. which had increased to 300,000, compared with estd. requirement of 75,000 cu m/day. Modifications to distribution system, piping system, filtration plant, and pumping system are described which give an immediate increase in supply to 100,000 cu m/day, with a supplementary supply of 50,000 cu m available in 2 stages of 25,000 cu m each. Replacement of piping system between Roguet and Bourassol saved 8,000 cu m/day; construction of new filter galley called La Padène supplied further 4,000 cu m/day, and diversion of water from Garonne, which had previously been abandoned in 1925, gave 2,000–3,000 cu m/day. Rest of increase in supply was attained by improving filters at Pech-David, including increasing load to sedimentation tanks, putting first 2 stages of sedimentation tanks in parallel, building 4 new sedimentation tanks, and installing 2 new tanks for disinfection with chlorine-ammonia.—*WPA*

(*Continued on page 98 P&R*)

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Installation of production facilities is proceeding on schedule, and is due to be completed in a few months. Modern automated machines will produce pipe by the Delavaud process of centrifugal casting in permanent water-cooled molds. Griffin-20 pipe joints will include slip-on, mechanical, and bell and plain end, and will be available for March, 1960 deliveries.

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Founded in 1877, Griffin operates 8 iron and steel foundries in the Midwest, two foundries on the west coast, and two in Canada. Also under construction is a new research center at Bensenville, Illinois. Griffin is a subsidiary of American Steel Foundries, which has 27 plants in 15 states and Canada.

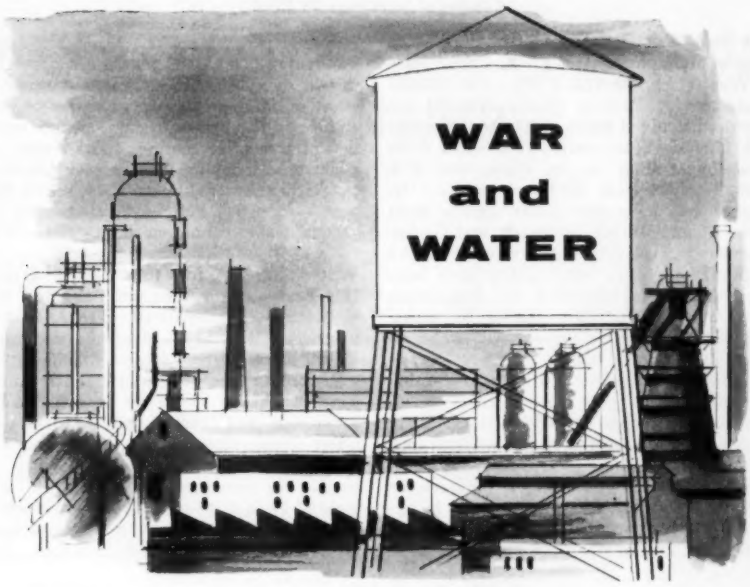
(*Continued from page 96 P&R*)

Technical Construction and Development of the Long-Distance Water Supply of Franconia (Ger.). J. MUTSCHMANN. Wass. u. Boden, **9**:90 ('57). Literaturber. Wasser, Abwasser, Luft & Boden, **6**:92 ('57). Long-distance water supply of Franconia, which has been under construction since '51, supplies a district of 2,200 sq. km with about 250 communities and 150,000 inhabitants, situated in western part of the Bavarian Jura. Water is drawn from the sandstone and alluvium of Main R. valley. To save pumping costs, high level supplies are mainly used but lower level supplies, some of which necessitate pumping in 3 stages, are used to meet peak demands. Organization and control of group supply are described.—*WPA*

The Ten-Year Plan for Water Supply (Ger.)—Brief Intermediate Balance. S. CLODIUS. Gas- u. Wasserfach, **98**:1051 ('57). Author surveys conditions at end of first 5 yr of 10-yr (1950–60) plan for water supply in West Germany, dealing with finance, past, present, and future demand, and relation between industrial production and water demand.—*WPA*

Experimental Plant for Treatment of Water From the River Main (Ger.) for Supply. K. STADAGER. Wass. u. Boden, **9**:103 ('57); LitBer. Wass. Abwass. Luft u. Boden, **6**:30 ('57). An exptl. plant for treatment of water from Main R. before its addition by seepage to ground water used for supply of Frankfurt is described. Plant, which has been in use since 1956, has a capacity of 70–80 cu m/hr. In prelim. flocculation tank with retention time of about 15 min, chlorine for oxidation and disinfection is added and also part of coagulant and sulfuric acid to reduce pH value to about 6. Water then flows to Accelator plant, in which remainder of coagulant is added, along with activated silica to shorten period required for sedimentation and milk of lime to neutralize acid water. Effluent is almost clear and colorless, odor has been largely removed, and bact. condition is satisfactory. Water then passes through closed sand filter and activated-carbon filter for removal of chlorine and residual taste, color, and odor and is distributed to seepage plants at 4 points, 30–150 m from intake wells of water works. Other chemicals as required can be added in Accelator plant.—*WPA*

(*Continued on page 100 P&R*)



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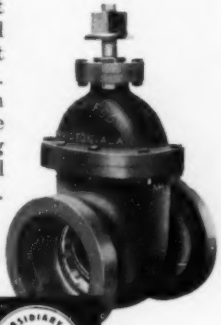
Industrial production requires over 5 billion gallons of water daily. Inadequate water supply could cripple or kill industrial operations as they can knock out a man. The basic materials used to make aircraft may be metals, but the metals themselves could not be produced without the use of water. It takes 150 tons of water to make 1 ton of steel.

When you see a military airplane soar through the air, or read of the latest missile shot to the moon—remember that behind the scenes, unsung and perhaps unknown, were the engineers and management of a modern water works system.



This Series is an attempt to put into words some appreciation of the water works men of the United States.

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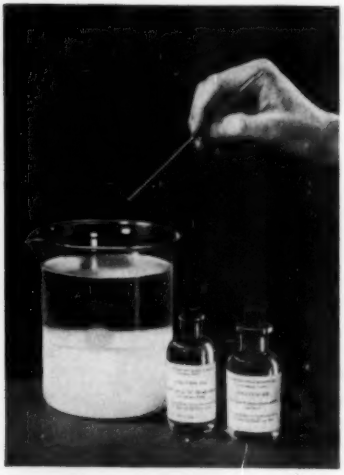
(Continued from page 98 P&R)

The Post-War Development of the Water Supply of Bremen (Ger.). A. OHL. Gas u. Wasserfach, **98**:911 ('57). Of 520,000 inhabitants of Bremen (Ger.), 440,000 are served with mixed water supply consisting of 68% filtered Weser water, 12% water from Soese impounding res. in Harz, and 20% ground water from Liebenau works. N. Bremen has a ground water supply from works of Blumenthal, Vegesack, and Grohn. Post-war reconstruction of river water works is described. Slow sand filters have been retained and are preceded by flocculation plant, and reaction and sedimentation tanks. Water from 2 other sources is added to filtered river water before it enters storage res. Progressive deterioration in condition of Weser water, with special reference to high chloride content caused by potash waste waters, is described and shown in diagrams, and analyses are given of filtered river water, added water, and mixed supply. Experience with Accelator plant, which has been in operation only for short time, is described briefly. Analyses are given of waters of 3 ground water supplies. These are treated for removal of iron, manganese, and free carbon dioxide. Expts. are in progress on effect of addition of silicates and phosphates on the removal of incrustations and formation of protective coatings. Brief accts. are given of distribution and storage plants, of efforts made to reduce poln. of Weser from potash industry, and of investigations into ground water conditions of district.—*WPA*

Water Supply for the Yeovil District (Gr. Br.)—Sutton Bingham Scheme. R. C. WALTERS & R. J. WALTON. Proc. Inst. Civil Engrs., **8**:71 ('57). Parishes comprising Yeovil Rural District formerly obtained their water from springs and wells. These sources were insufficient to satisfy growing demand for water, and it was decided to impound water from river Yeo. As Borough of Yeovil also required supply of water, it was decided to construct res. to provide gross yield of 2¾ mgd, of which one-third would be required by Yeovil Corp., and ½ mgd would be available as compensation water. Con-

(Continued on page 102 P&R)



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(*Continued from page 100 P&R*)

struction of res. is described in detail. Treatment plant is designed to treat 2 mgd in period of 16 hr. Treatment comprises preliminary chlorination for control of algal growths in sedimentation tanks, coagulation with aluminium sulfate and sodium aluminate, sedimentation, rapid gravity filtration, neutralization if necessary by addition of up to 50 ppm lime, and chlorination. Provision has been made for addition of activated carbon if necessary to control tastes and odors.—*WPA*

Coordination of River Interests (Gr. Br.): An Anglo-Welsh Example. G. A. WRIGHT. J. Inst. Water Engrs., 12:297 ('58). Advantages of cooperation between water undertakings requiring water from particular river basin, and between undertakings and appropriate river boards are explained and illustrated by reference to use of river Dee, particularly Bala lake scheme, completed in 1956 with a tot. authorized abstraction of 48 mgd; and proposed scheme for supplying water to Liverpool from the river Tryweryn, chief tributary of Dee. This scheme includes construction of a dam across the river, the creation of an impounding res. capable of yielding 65 mgd in addition to compensation water, use of natural river channel as an open conduit between dam and a works constructed at Huntington, 3 mi upstream from Chester weir, installation of pumping facilities and aqueduct to convey abstracted water to existing reservoirs near Prescot, Lancs., and diversion of various surface waters to Tryweryn res. A map is included showing position of proposed res. and catchwaters diverting water into res., and diagram is given to show relative positions of abstraction of water from river Dee system and amts. authorized to be abstracted by each undertaking. Regulation of sluices of Tryweryn res. dam will be subject to directions of Dee and Clwyd R. board, which already controls sluices of reservoirs in Bala lake scheme. All sluice regulation will be determined by amt. of river discharge at Erbistock, 44 mi downstream from Dee-Tryweryn junction. It is emphasized that in river planning there must be careful, systematic, and accurate measurement of river flows.—*WPA*

(*Continued on page 104 P&R*)

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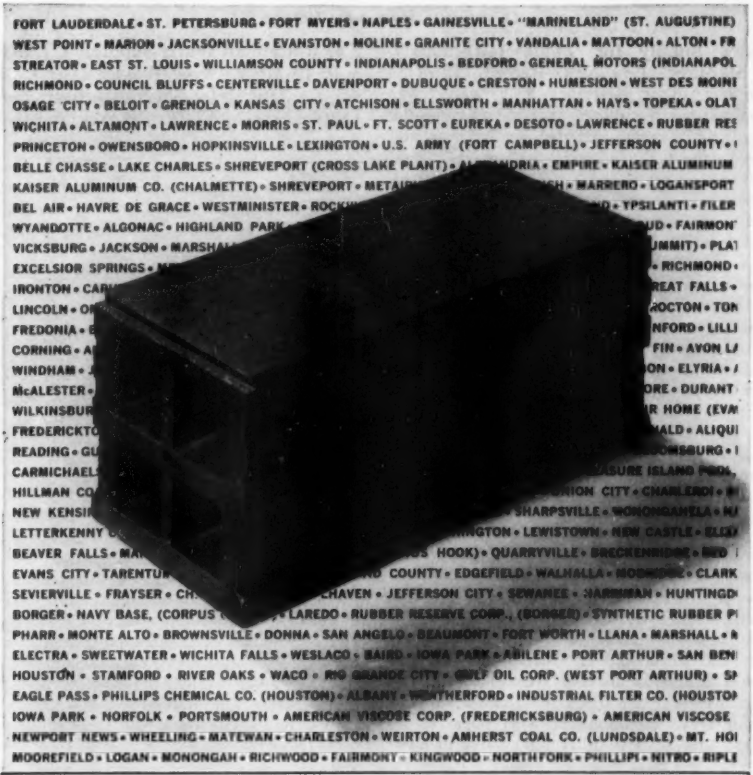
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Leopold

GLAZED TILE FILTER BOTTOMS

(*Continued from page 102 P&R*)

Water Supply for Thule (Greenland). M. SOLOMON. Eng. News-Record, **156**:24:53 ('56). Author describes how water was supplied to US air base at Thule, Greenland. Available sources included melted ice and snow, deep wells, natural shallow lakes and distilled sea water. First 2 were abandoned, distillation of sea water tried but found too costly, and supply was obtained from shallow lakes, below ice level in winter. Crescent L. was chosen, pumping station and treatment plant built. Treatment includes introduction of limestone, ferric chloride, and calcium hypochloride into water in Erdlator, followed by pressure sand filtration. Water is distributed by insulated trucks. In subzero weather a blowtorch keeps water above freezing point. Sewage disposal at Thule is carried out by storage tanks and heated disposal trucks, which haul it to central point from whence it is carried away by an electrically heated and insulated sewer and discharged into the bay 300 ft offshore.—*WPA*

Water Supply From Deep Wells in the Low Plains of Hungary. W. SPERLING. Gas- u. Wasserfach, **98**:1003 ('57). Author summarizes contents of 2 papers. Conditions of water supply in low plain of Hungary and advantages of small water supplies with 1–2 deep wells and yield of up to 300 liters per min are discussed. Such supplies would serve communities with pops. up to 5,000; 43% of pop. of Hungary live in communities of this range of size. Hydrologic conditions and methods of construction of deep wells for small supplies and investigations into composition of deep waters are described.—*WPA*

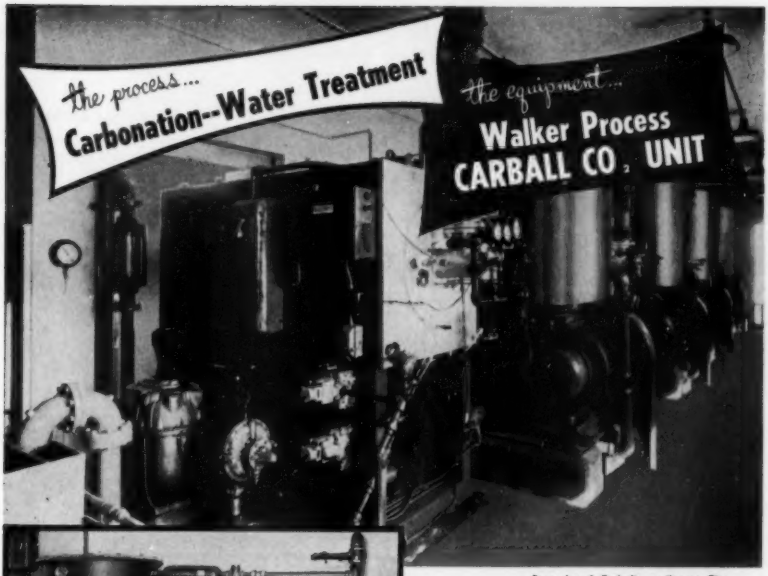
A Water Supply for Lamu (Kenya). C. WRIGHT. J. Inst. Water Engrs., **11**:599 ('57). Fresh ground water supplies in island of Lamu, off coast of Kenya, are found only overlying sea water, and special type of well has been designed in attempt to provide adequate supplies of potable water for the 9,000 inhabitants. Water enters well horizontally through porous concrete and passes into small storage res. from where it is periodically pumped. Water is stored in res. capacity 100,000 gal, having been previously chlorinated by a drip-feed dosing apparatus at inlet to res. Fresh ground water is replenished only by local rainfall, and in periods of drought it may be necessary to restrict consumption.—*WPA*

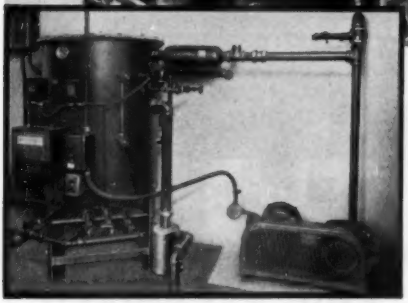
The Rotterdam Water Supply. J. J. BIJKER & E. L. MOLT. Vom Wasser (Ger.), **24**:31 ('57). After brief illustrated description of water works of Rotterdam and processes of treatment, author discusses chemical principles of methods of treatment used, dealing with reactions involved in breakpoint chlorination, methods of determining breakpoint, preparation of ferric chloride by action of sol. of chlorine on iron plates, method of adding coagulant, method of detg. amt. of coagulant required, and factors affecting coagulation. Results of analysis show that method of treatment adopted produces from pold. river water a supply which is physically, chemically, and bacteriologically satisfactory. At times when condition of Rhine water is especially bad, it is treated with active carbon at intake.—*WPA*

Hydrological Investigations in the Netherlands. I. Ground Water Problems and Ground Water Investigations in the Netherlands. W. F. KRUL. Ingenieur, 'sGrav., **70**:75 ('58). Importance of control of ground water in Netherlands is emphasized in relation to problem created by increasing water demands of densely populated country for domestic, industrial, and agricultural use. Acct. is given of hydrogeological investigations carried out in Netherlands during last 70 yr, on behalf of water supply industry, in relation to hydraulic engineering works, and in connection with agricultural problems. Maps are included showing positions, throughout country, of pumping stations drawing ground and/or surface waters, and of hydrogeological investigations; and giving hydrological data on watersheds in Gooi, and system of exptl. borings used in hydrogeological survey of the Wieringer Meer.—*WPA*

General Thoughts on the Drinking Water Supply of the Capital and Adjacent Islands (Port.). B. PINHO. Bul. Mens. Centre Belge Etude et Document. Eaux, **68, 69**:343 ('56). Water supply of Lisbon is obtained from ground water brought by Aguas Livres aqueduct, water being treated by coagulation with aluminium sulfate, rapid gravity filtration, ammoniation and chlorination; from source of Alviela R., by means of Alviela aqueduct, water being treated with combined chlorine; and from wells on right bank of Tagus R. Water supplies of Oporto

(*Continued on page 106 P&R*)





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(*Continued from page 104 P&R*)

and other towns in Portugal are also described. Most waters are treated with gaseous chlorine or sodium hypochlorite before distribution. Assistance given by state for construction of treatment plants in rural areas is described.—*WPA*

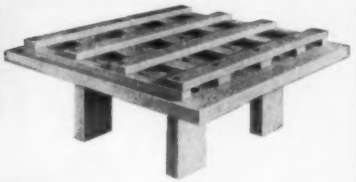
Glasgow (Scot.) Corporation Garthamlock Works. Civil Eng., Lond., **53**:60 ('58). To augment supply of water to outlying eastern areas of city of Glasgow, main has been laid to take water from Ruchazie Res. and pumping station, 3-mil gal service reservoir, and 1-mil gal water tower have been constructed at Garthamlock.—*WPA*

Bethulie Bridge and Water Supply for the Cape Eastern Main Line (S. Afr.). Engr., Lond., **204**:431 ('57). A new water plant has been constructed on north bank of Orange R. to supply water for locomotives of the Cape Eastern Main Line of South African Railways. As water is very muddy, prelim. sedimentation tank was designed specially to remove heavier silt portion from water. Water is then filtered and stored in 2 100,000-gal storage reservoirs before being passed to steel tanks which supply water columns where locomotives are watered.—*WPA*

Water Supply of Aleppo (Syria). E. WALTER. Gas, Wasser, Waerme, **11**:33 ('57). Brief acct. is given of water supply problems and difficulties of Aleppo up to '45 when survey was begun to find source of sufficient and satisfactory supply. Only source of sufficient supply was found to be Euphrates R., which has avg. annual flow of 15–90 billion cu m. Annual water demand of Aleppo was calculated as 23,000,000 cu m in '75. Construction of intake plant in river is described. River water has high, often very high, content of suspended matter. At intake, therefore, screens and settling channel, with automatic sludge removal, precede raw-water pumps, which pump water 23 m upward to filtration station. Filtered water is

(*Continued on page 108 P&R*)

feco FRE-FLO
FILTER BOTTOMS



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70-B ENAMEL

(Continued from page 106 P&R)

pumped 100 m upwards and then flows 81.9 km to town, where, after treatment with ozone, third rising main 49 m high conveys it to the high-level res. Stages in which work is being carried out are described. Filtration plant comprises enclosed filters with plant for addition of alum and lime, and sedimentation tanks on Accelator system. This plant and associated chemical labs. are described and illustrated and acct. is given of construction of rising mains and of main aqueduct, which is laid in open channel. Ozone treatment plant, on eastern boundary of town, is preceded by rapid filter plant to remove organic matter introduced in journey from main filtration plant. Ozone plant and effect of treatment are described.—*WPA*

The Water Supply of the Town of Istanbul (Turk.). S. NAZIM. Eau (Fr.), **44**:129 ('57). Historical acct. is given of growth of water supply system of Istanbul, with special reference to construction of dams and reservoirs. 2 reservoirs, having capacities of 1,600,000 cu m and 609,000 cu m, provided an adequate water supply until end of last century, when water was also obtained from Terkos L., which has capacity of 250,000 cu m. Owing to increase in pop. of Istanbul, supply in Terkos L. was supplemented by further 10,000 cu m, and, in '50, town's supply was further supplemented by an additional 140,000 cu m. New electric pumping station was constructed, and extensions to treatment plant which comprises sedimentation tanks and filters, are being carried out. Another reservoir, which will have capacity of 11,000,000–16,000,000 cu m, is also under construction to serve portion of city on right bank of Bosphorus.—*WPA*

Geological and Hydrochemical Investigations in the Eastern Vorderpfalz Between Worms and Speyer. G. MATTHESS. Notizbl. Hess. Landesamtes Bodenforsch. Wiesbaden (Ger.), **86**:335 ('58). Generally tot. hardness of ground water in Eastern Vorderpfalz varied between 20 and 40 deg of German hardness. Majority of values for chloride content were between 50 and 150 mg Cl/l. Values >150 mg were dispersed irregularly, values of <50 mg are detd. in ground waters near Rhine and other open waters. From Bunter Sandstone a water with small quant. of chloride and sulfate proved typical. In Pleistocene gray series iron content was between 0 and 5.64 mg/l. Fe content in waters from low-lying terrace was mainly between 0 and 2.0 mg/l (104 samples); 16 samples showed values between 2.0 and 7.6 mg Fe/l. While chloride content in ground water of areas with forest was only 6.4–11.7 mg/l, values amtd. to 69.4–85.2 mg/l in areas with agriculture. In areas with human settlements (Ruchheim) chloride content varied from 76 to 405 mg Cl/l. Ground waters of deeper levels are sodium bicarbonate waters with a tot. hardness of 9–18 deg German hardness and contents of chloride = 2–14, of sulfate = 0–23, of nitrate = 0.15, and of iron > 1 mg/l.—*CA*

Boron Content of the Saale River. F. HEIDE & A. THIELE. Naturwissenschaften, (Ger.), **45**:363 ('58). The B content in soln. and suspension has been detd. monthly during 1955 at one point of the stream and at 9 points along its course at one time. At Göschwitz, near Jena, the mean value of the Dissolved B is 41 γ/l. It varies inversely with stream flow and directly with the salinity.—*CA*

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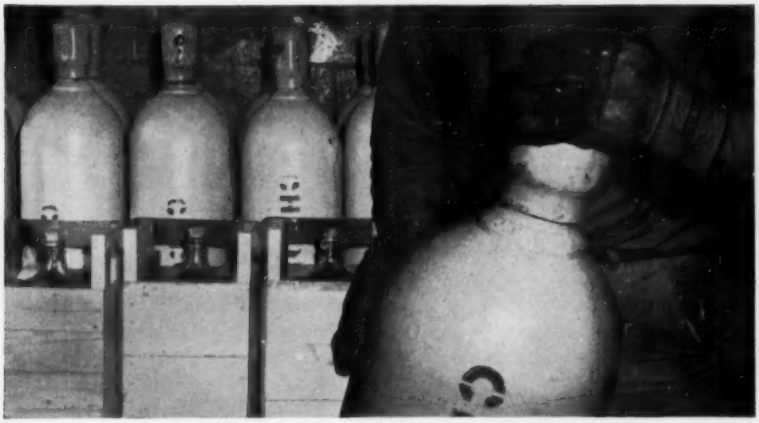

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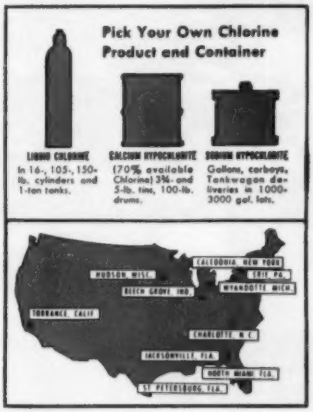

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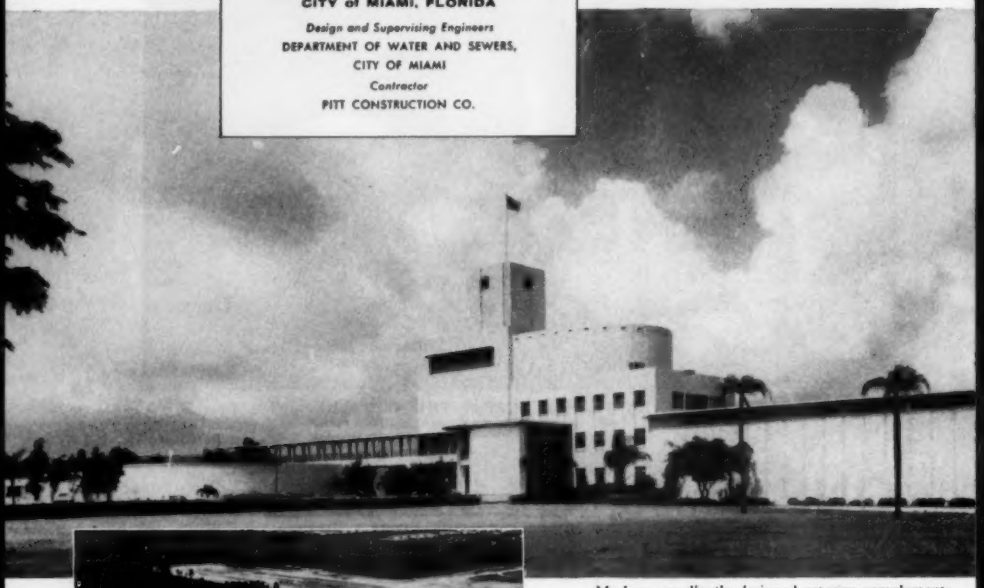

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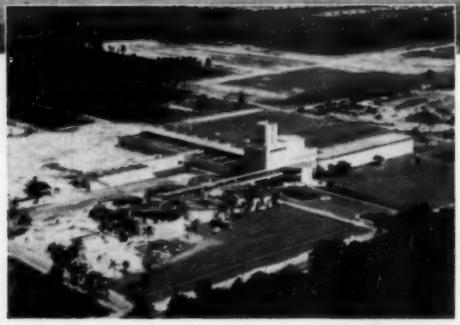
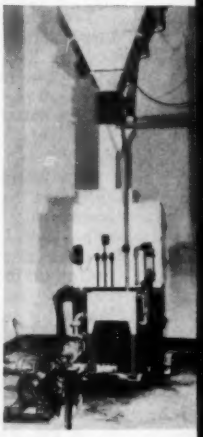


Aerial view shows the extensive layout required to treat water from the high capacity wells in the Everglades and at plant site.



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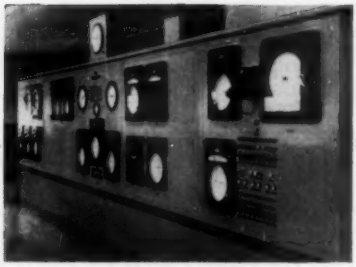
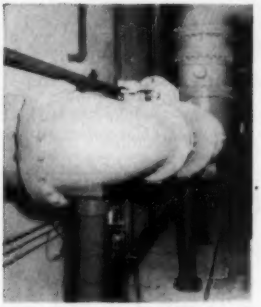


Builders Master Control Panel serves as centralized information center for operating entire plant. Panel provides supervisory control of well field, indicates all flows entering and leaving plant, indicates amount of chemicals being fed, and pressures both at plant and in downtown area.



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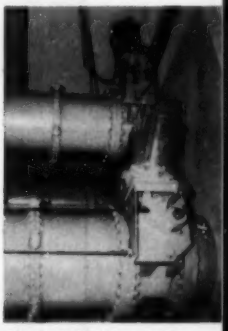

Compact Builders rubber-lined AWWA Butterfly Valves are equipped for both automatic and manual emergency operation . . . have many exclusive design features for efficient "bubble-tight" operation.

(Continued from page 56 P&R)

"Rent vatten" is the motto of Erik Jonsson. The distinguished secretary of the Swedish Association for Water Hygiene (pictured at left) was introduced to Harry E. Jordan last May, when both were attending the meeting of the British Institution of Water Engineers. Mr. Jordan insists that not only the name and the occupation, but even the face and manner of speaking, were familiar—seemed to remind him of someone (see December 1958 P&R, p. 36).

Rent vatten? Clean water, of course. And what's more, all the vatten you vant, vhen and vhere you vant it.

Daniel Bergsma has resigned as New Jersey state health commissioner to become associate director of medical care for the National Foundation. Roscoe P. Kandle has been nominated to succeed him.

Warren C. Westgarth, associate professor of sanitary engineering at Oregon State College, has left to engage in doctoral research in sanitary engineering at the University of North Carolina.

Kenneth E. Shull, vice-president in charge of public relations and water quality control for Philadelphia Suburban Water Co., Bryn Mawr, Pa., has been appointed vice-president—research by the company. In his newly created position, he will formulate programs and policies on water treatment and allied research.

That women's appreciation of water is both strong and constant is underlined by two news items which crossed our desk recently. The first, datelined Mar. 20, 1879, from Virginia City, Nev., read:

> The water company has planted a row of trees on B Street in front of their office. This is in order that the clerks may be able to keep cool when old women come in to abuse them for cutting off their water.

The second, datelined Jun. 22, 1959, from Durban, South Africa, noted:

> A crowd of 200 African women at the Kwa Mashu township northeast of Durban proper demonstrated outside the municipal building and threatened to cut the water pipes that supply the town. The women protested the metering of water in the district. When they ignored orders to dispense, police hurled three tear-gas shells.

Public relations problems seem to have changed little over the years, and in their solution it is doubtful that the

(Continued on page 114 P&R)

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LIFE

(Continued from page 112 P&R)

modern scientific method of moving women to tears is nearly as effective as the old techniques.

B. E. Payne, chief engineer of Louisville (Ky.) Water Co., has been named its general manager as the first step in a plan to curtail the powers and prerogatives of the now vacant company presidency, an office that could become a political plum with its salary of $11,000 and the use of a mansion and Cadillac rent free. Under the plan proposed by Mayor Bruce Hoblitzell, who is ex officio a director of the company, the presidency would no longer be a full-time job with operating responsibility; instead, the chief engineer and general manager would be in charge of day-to-day operation, and the president would serve as chairman of the board, with his duties confined to policy making. Before the change in the president's powers can take effect, the state legislature will have to pass an enabling act. Meanwhile it is expected that the presidential post will remain unfilled.

The SEATO Graduate School of Engineering is being established in Bangkok, Thailand, under the auspices of the International Cooperation Administration. A comprehensive reference library is planned. Engineering literature in the form of periodicals, books, manuals, microfilms, special reports, and the like is being solicited. Write: Dr. Maurice L. Albertson, Director, Colorado State University Research Foundation, Fort Collins, Colo.

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Expanding sales and research in our field of sewage and waste treatment and water purification has created openings in our staff for *one senior* and *two junior sanitary engineers.*

These technical executives will be stationed at our plant and general offices in Aurora, Illinois.

Write in complete confidence and in detail giving us all the information you feel we will require to lay the foundation for a personal interview.

Office of the President
THE AMERICAN WELL WORKS
Aurora, Illinois

Dwight D. Gross, consulting engineer, Board of Water Commissioners, Denver, Colo., died Jul. 9, 1959, at the age of 79. Born in Friend, Neb., he received a degree in civil engineering from Colorado A&M College in 1903. He joined the Denver Union Water Co. as concrete inspector, became a draftsman and field engineer in 1906, and was promoted to chief draftsman in 1919, shortly after the company was purchased by the city of Denver. He became chief engineer in 1926, a position he held until his retirement in 1951. The largest project he supervised was the construction of a $12,000,000 reservoir and dam, which was named Gross Reservoir in 1955.

An AWWA member since 1925, Mr. Gross received the Fuller Award in 1944 on nomination of the Rocky Mountain Section. He served the Association as director from 1946 to 1949 and became a Life Member in 1955. He also belonged to ASCE.

2.

3.

1. Large illustration shows Singl-use Fiberform ready to be filled.
2. Filling plate and collar simplify pouring concrete into form.
3. Completed meter box barrel.
4. Meter box with cover in place.

4.

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AW-9 Money Clip (Rhodium Plated)	2.75
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AW-11 Earrings (Screw Type)	2.50
AW-12 Knife-Money Clip (Rhodium Plated)	1.75

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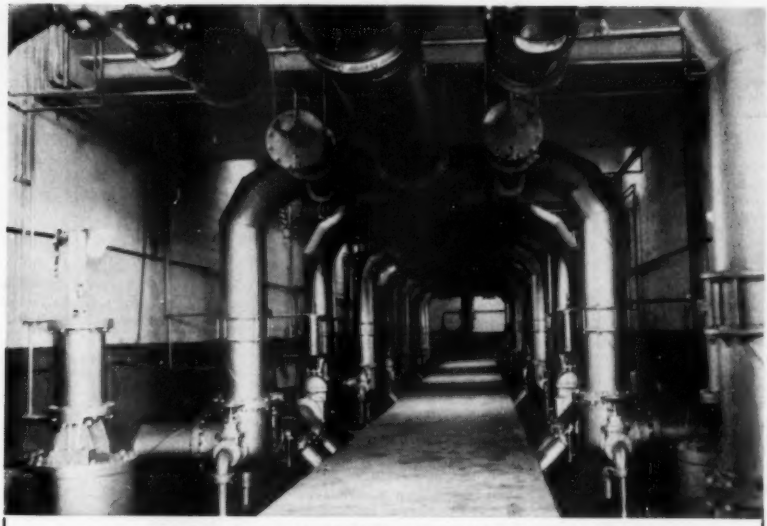
Clarifiers are discussed in a new, illustrated, 4-page bulletin, which describes equipment for coagulation, flocculation, sedimentation, and sludge removal. Bulletin SM-1013 may be obtained from Process Engineers, Inc., 420 Peninsular Ave., San Mateo, Calif.

Trenching equipment for service installations is described in a 4-page, illustrated brochure that discusses an automatic unit for digging trenches 2–3 in. wide and down to a 3-ft depth. Information on the "Davis Pup" is available from Davis Mfg., Inc., 1301 S. Handley, Wichita, Kan.

Valves are the subject of a 24-page, illustrated booklet that includes photographs, cutaway drawings, and complete specification data. This information is contained in Bulletin V-612, available on request from Rockwell Mfg. Co., Pittsburgh 8, Pa.

Fluid processing is discussed in a new 16-page booklet that explains "Fluidics"—a scientific approach to the handling of liquids in industry. Bulletin 980 is available from Pfaudler Div. of Pfaudler Permutit Inc., 1094 West Ave., Rochester, N.Y.



Armco Welded Steel Pipe installed in pipe gallery of El Placer Water Purification Plant, Quito, Ecuador.

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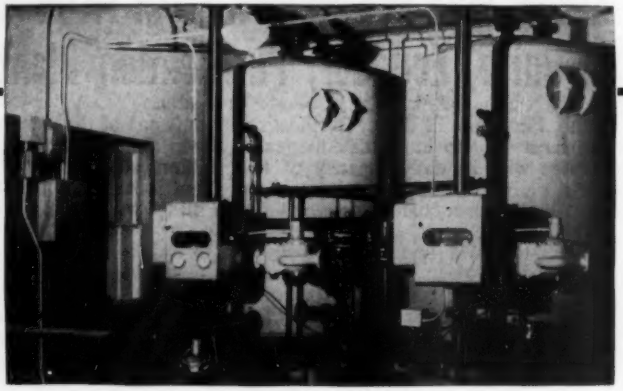

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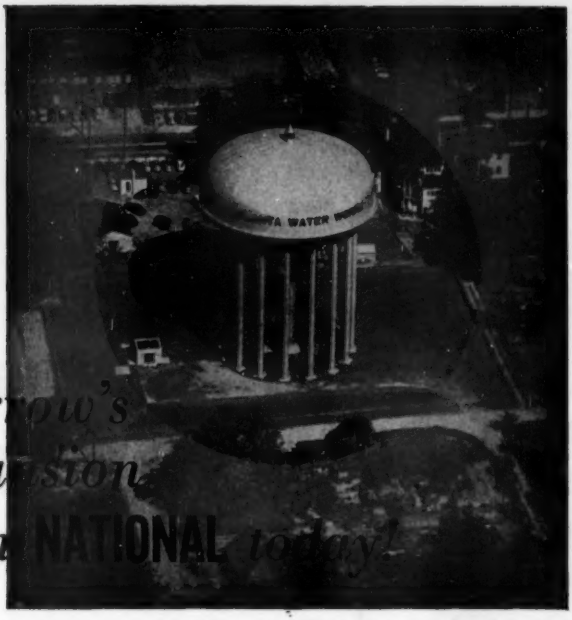
B-I-F Industries, Inc.—Builders
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.
Valves, Large Diameter:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.
Valves, Regulating:
Allis-Chalmers Mfg. Co., Hydraulic Div.
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.
Venturi Tubes:
B-I-F Industries, Inc.—Builders
Simplex Valve & Meter Co.
Waterproofing:
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.
Wilbur & Williams Co., Inc.
Water Softening Plants; see Softeners
Water Supply Contractors:
Layne & Bowler, Inc.
Water Testing Apparatus:
LaMotte Chem. Products Co.
Wallace & Tiernan Inc.
Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.
Well Drilling Contractors:
Layne & Bowler, Inc.
Well Reconditioning and Formation Testing:
Halliburton Oil Well Cementing Co.
Layne & Bowler, Inc.
Wrenches, Ratchet:
Dresser Mfg. Div.
Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1957 AWWA Directory.



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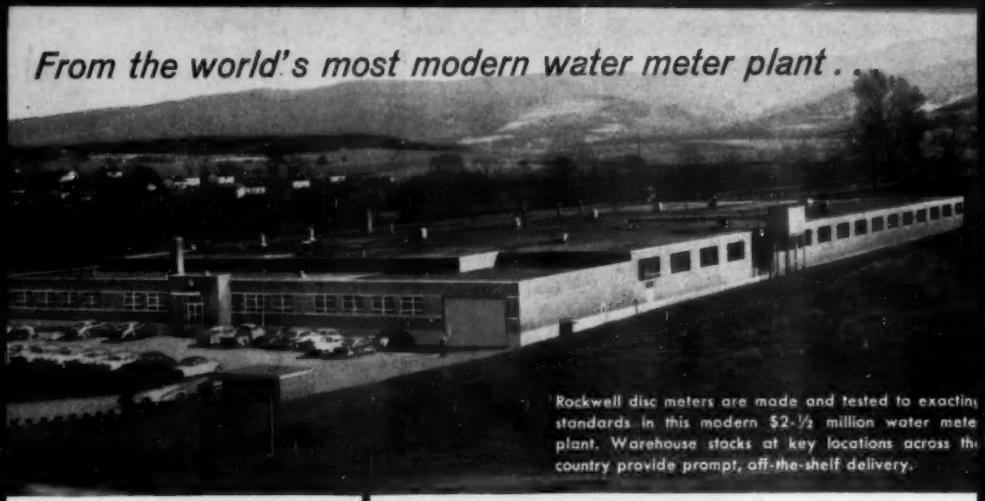

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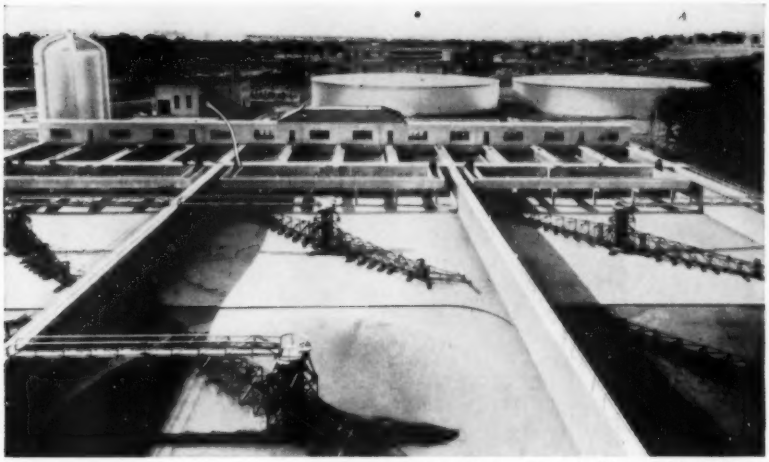

Consulting Engineers: Freese & Nichols, Ft. Worth, Texas
Contractor: C. H. Leavell & Company, El Paso, Texas

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As in so many other water treatment facilities across the country, the engineers for this project realized maximum efficiency and economy of design in the wide choice offered by Dorr-Oliver equipment. For complete information, write for a copy of Bulletin No. 9141 to Dorr-Oliver Incorporated, Stamford, Conn.

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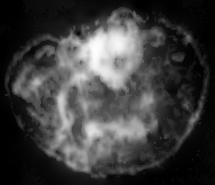
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